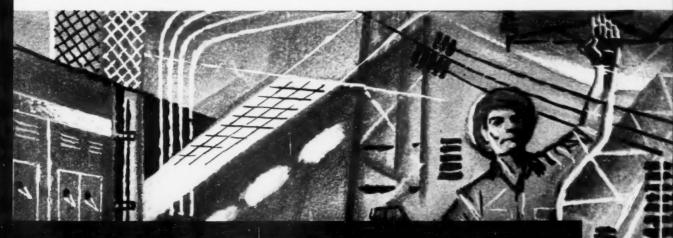
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WITH ELECTRICAL CONTRACTING



AN ORIGINAL BOOK-LENGTH MANUAL

Constructing Electrical Systems



A McGRAW-HILL PUBLICATION

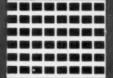
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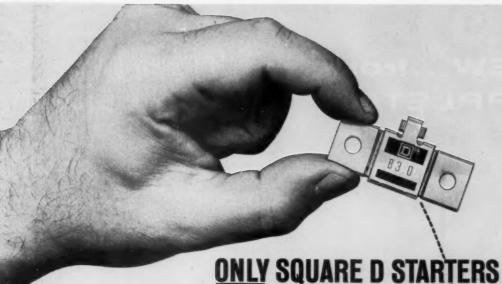
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Vol. 59, No. 5

May 1960

### ELECTRICAL CONSTRUCTION and MAINTENANCE

und MAINTENANCE

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ACCURATE MANUFACTURING COMPANY Garlield, New Jersey Government economists are not all as optimistic about business prospects for 1960 as they were around the first of the year. Some of the statistics on national economy yardsticks have reflected declines, or growth slowdowns, during the first quarter of the year. But the Administration blames record blizzards, heavy snowfalls, and unusually low temperatures during February and March for slowdowns in construction, retail sales, etc., and still maintains that 1960 will be a record year in most types of business. Gross national product is expected to cross the \$500 billion annual rate in the second quarter of this year.

Average family income in 1959 was \$6,520, in the U. S., according to Dept. of Commerce. This was 4% more than for the year before. In comparison, however, Government spending (Federal, State and local) is also increasing from year to year. Gross spending by all Federal agencies in fiscal 1960 will total about \$98 billion, up from about \$84 billion in 1958. Government spending of all types now totals about one-third of the entire national income, according to a recent estimate of Treasury Secretary Anderson.

Cost-of-living moved up again in February to an index figure of 125.6% (of the 1947-49 average), same as the record high reported for last November. The index had declined slightly during December and January. Labor Department spokesmen forecast a modest gain in consumer prices during 1960 of about 1.5%.

Total new construction will reach a record of about \$57 billion this year, according to recent estimate of Associated General Contractors of America, Inc., up more than \$1 billion from the Government's December estimate of \$55.3 billion. In addition, AGC spokesman predicted maintenance and repair dollar volume will total about \$20 billion, up \$1 billion from 1959's record \$19 billion.

But most contractors expect profits to decline, in spite of increased dollar volume. Reasons: the industry's capacity far outstrips the rise in dollar volume, wages are increasing, and materials prices continue to rise.

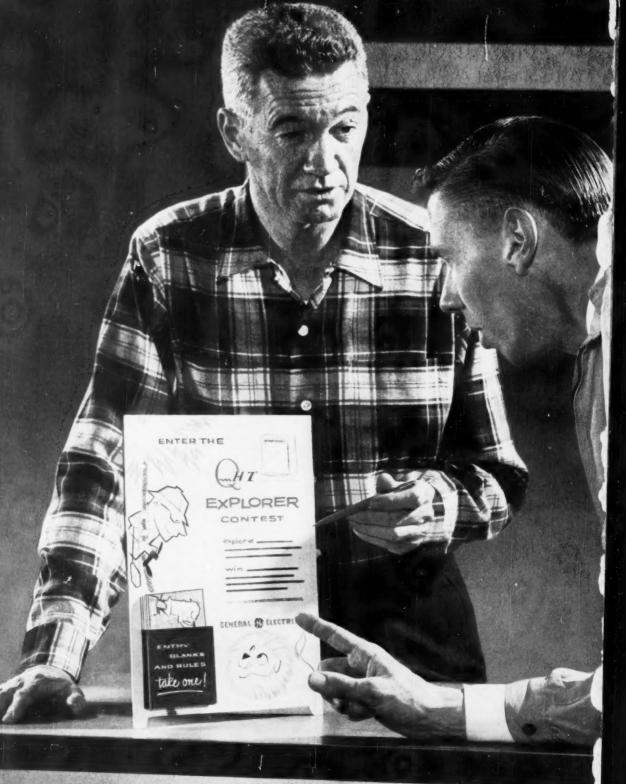
New construction outlays in March were up 5% from February, to \$3.7 billion, and about 4% more than for March 1959, according to Dept. of Commerce report. Construction spending for the first three months of 1960 totaled \$10.9 billion, or 2% below the like period last year.

Housing starts rose seasonally during March, which is normal, but the seasonally-adjusted annual rate was still only 1,115,000 units, less than the 1.2 million units previously forecast for the year by Government officials. March starts totaled 93,800, up from 74,400 in February.

School construction requirements for the next ten years add up to 607,600 classrooms, costing an estimated \$26.8 billion, according to a recent report prepared by the U. S. Office of Education.

Copper production during March set a new all time record on the basis of combined domestic and foreign output. U. S. mines output and scrap intake totaled 117,161 tons, and foreign producers turned out 199,784 tons. This reflected the return of U. S. mines to full production following settlement of long strikes around the first of the year, as well as increased output from new mines and expansion of others.

"George, you should KNOW all







... that's right, KNOWING the features of OHT dry-type transformers means satisfaction, can save time and money, and may win you a vacation of your choice in New York. Miami, Las Vegas, or Los Angeles



General Electric QHT dry-type transformers provide a balanced combination of small size, light weight, superior installation features, hightemperature insulation, and quiet operation. This combination means easier installation and practically eliminates the major sources of transformer complaints-noise and insulation failure. Review these features:

Ease of installation. These General Electric OHT dry-types are built with convenient conduit knock-outs, large terminal compartments, and wiring spaces which are easily accessible from the front. You'll save time and money every time you install one.

Quiet, high-temperature operation. All QHT transformers have sound levels equal to or less than NEMA Standards. The rigid, welded design of the units helps eliminate vibration, and built-in rubber mountings reduce noise transfer through conduits and mounting brackets. QHT dry-types have silicone-impregnated insulation, highly moisture resistant, with an inherent ability to withstand high operating temperatures.

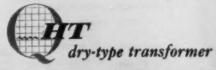
Small size, light weight. Because these new QHT dry-type transformers are built of quality, weight-saving materials such as aluminum conductors and cold rolled, grain-oriented silicone steel, you get a unit that's lighter and smaller than old type designs. You'll save space and money in installation by putting these new transformers right at the load.

Fast delivery. Complete stocks of these new General Electric QHT drytype transformers are available at your local G-E electrical distributor. See him today for all the information on what these QHT features mean to you. And ask him for details on the "QHT EXPLORER CONTEST"-he'll give you all the details and an entry blank.

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announcing the



### PLORER

CONTEST

You can win a vacation for two in your choice of New York, Miami, Las Vegas, or Los Angeles, or one of 1400 other prizes, simply by exploring the world of extra values in General Electric QHT dry-type transformers. Call your G-E dry-type transformer distributor and ask him for details on the "QHT EXPLORER CONTEST"he'll give you all the details and an entry blank. 411-14

No entries will be accepted from employees of the General Electric Company or its subsidiaries.

GENERAL & ELECTRIC

### **Sidelights**

### **ELECTRICAL CONSTRUCTION TECHNIQUES**

Most of the editorial contents of this issue is devoted to an original, book-length editorial feature, "Constructing Electrical Systems." The project is essentially complementary to "Electrical Systems Design" which appeared in the May 1959 issue and deals with the application and installation of electrical systems with detailed references to the pertinent provisions of the National Electrical Code. Past experience indicates that many of our subscribers and their associates will want copies of this project in a permanent reference form. Preparations are being made to offer a hard-cover book edition of "Constructing Electrical Systems" at an early date. Check this page next month for details and prices.

### ELECTRICAL SYSTEMS DESIGN.

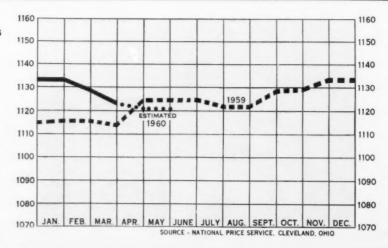
Just off the press this month is the Second Edition of "Electrical Systems Design" by Joseph F. McPartland and the Editors of Electrical Construction and Maintenance. The new edition involves an extensive revision of the original work and a great deal of new data has been added. It covers modern standards, procedures and developments in electrical systems design for power, light, heat, air conditioning, signals and communication. Code requirements are correlated with engineering considerations. The new edition not only reflects recent advances in systems design, but also incorporates the most recent changes in the code. While the work was intended primarily for the professional as a basic guide and reference to modern practice, it also has been widely used as a textbook for courses in electrical construction design. "Electrical Systems Design," Second Edition, is published by the McGraw-Hill Book Co. and priced at \$7.75.

### RESIDENTIAL RACEWAY SYSTEM

A wiring system using surface metal raceways exposed on the basement ceiling to carry high capacity feeders is among the novel methods employed in a new Gold Medallion home built for William E. Parks in Plantsville, Conn. No. 6, 3-wire, feeder circuits originating at the service entrance panel extend about two-thirds of the length of the basement in three metal raceways. Branch circuit breakers are installed on the raceways directly under or adjacent to the various appliances and circuits served. The method permits very short individual appliance branch circuits and home runs. A detailed description of the installation will appear in the June issue.

### ELECTRICAL MATERIALS COST INDEX

BASE LINE (1000) REPRESENTS COSTS OF TYPICAL ASSORTMENT OF MATERIALS FOR A SELECTED JOB AS OF NOVEMBER 1, 1951. INDEX POINTS REPRESENT THE VARIATION OF THESE SAME MATERIAL COSTS AS OF THE FIRST OF EACH MONTH.



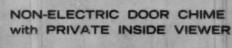


PRIVATE VIEWER INSIDE DOOR



MC-309 \$7.95 list

\$13.95 list.



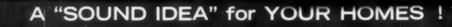
Protection for the home! No need to open the door when strangers call. The optical lens gives a "wide angle" view of entire door area. Sounds two chime notes. No wiring is needed. Easy to install in doors 3/4" to 2" thick.

See Next Page -

23 HANDSOME STYLES . . BUILT-IN or SURFACE MOUNTED



FREE COLOR CATALOGS . . . write NUTONE, Inc., Dept. AB-5, CINCINNATI 27, OHIO





# Autone Intercom and Radio

# A Step-Saver for Busy Homemakers!

ROOM-TO-ROOM INTERCOM . . ALSO AM-FM RADIO IN EVERY ROOM

No extra walking . . no loud shouting . . just speak softly into any speaker to be heard in every room . . or patio.

- Two-way outside remote lets you talk to strangers without opening the door.
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NuTone Intercom leaves both hands free for installation. Boxes adjustable to the wall line.

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Nothing sells your homes like built-in music in every room.

Central NuTone system "pipes" music throughout the house . . . and patio too.

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### WAGNER UNIT SUBSTATION TRANSFORMERS



VENTILATED DRY-TYPE—For indoor installation in reasonably dry, dust-free, well ventilated locations. Light in weight, ideal for multi-story buildings. No fireproof vaults required. Insulated for 80°C temperature rise.

1121/2 to 2000 Kva - three phase, 60 cycles, 15 KV and below

for your plant's electrical system...



OIL-FILLED—Generally installed outdoors. Can be used indoors in fireproof vaults. Outdoor transformers can be connected to indoor switchgear using weather-proof bus-duct. 55°C rise, self-cooled or forced-air cooled.

### SELECT WAGNER

There's a complete line of Wagner Industrial Transformers. One or more of them will fit your specific needs whether you're planning a new plant distribution system, modernizing your present one, or adding to its capacity to meet increasing demands for power. So, select and specify Wagner Transformers. They'll give you long, dependable service because:

All Wagner Industrial Transformers are liberally designed, sturdily constructed, thoroughly tested, and able to meet the heaviest industrial demands. You get continuous, dependable power for years,

For your main plant substation, Wagner Liquid-Filled Industrial Power Transformers are available in standardized ratings through 10,000 Kya.

Load centers? Wagner makes PREDESIGNED Unit Sub-

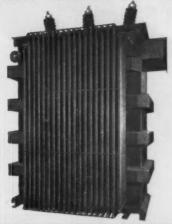


NOFLAMOL—Non-inflammable liquid-filled. For indoor or autdoor installation, especially suited for chemical plants, refineries and similar locations where explosive liquids or gases are present. The close-coupled design fits flush against switchgear enclosures to save space. Throat connected designs are also available. 55°C rise, self-cooled or forcedair cooled.



SEALED DRY-TYPE—Hermetically sealed in welded steel cases to provide positive protection from contamination, fire and explosion hazards. Sealed tank is filled with inert nitrogen. Only maintenance needed is periodic checking of gas pressure. Can be safely installed in any load center.

### WAGNER INDUSTRIAL POWER TRANSFORMERS



Oil-filled, for outdoor installations, available through 10,000 Kva, 67 KV and below.

Noflamol, non-inflammable liquid-filled for explosive atmospheres, available through 7,500 Kva, 15 KV and below.

The performance stability of Wagner Industrial Power Transformers is outstanding. Quality is designed and built into these transformers by specialists with years of transformer engineering and production experience. Highest quality materials...carefully controlled production methods...constant inspections and tests make sure these transformers give in-service performance that means better service for your system.

### INDUSTRIAL TRANSFORMERS

station Transformers to meet your particular requirements. Furnished with suitable incoming line sections, these transformers will save you time and job engineering costs. And, you can specify the secondary switchgear you prefer.

Wagner Dry-Type Distribution Transformers are an economical choice for plant areas requiring 120/240 volts, single-phase or 208Y/120 volts three-phase.

Over 65 years of constant research and development has made Wagner a leader in transformer design...made the name Wagner one of the foremost in power planning. For expert advice on your present and future plant transformer needs, call or write the Wagner branch near you.

get economical, dependable, power packages!

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### WAGNER DRY-TYPE DISTRIBUTION TRANSFORMERS





Single-phase 1 to 100 Kva—Three-phase 3 to 300 Kva—600 volts and below.

These dry-type distribution transformers have a low sound level, are compact and light in weight. They meet all safety requirements for indoor installation. They are economical to maintain... have no liquids, valves, gaskets or gauges.

Type AE, single-phase, 1 through 50 Kva, and Type AP, three-phase, 3 through 30 Kva, can be installed indoors or out. Larger ratings for indoor installations only. Ratings through 10 Kva single-phase are filled with an epoxy compound...operate quiet as a whisper...perfect for areas where noise would be a nuisance. They, and three-phase units through 30 Kva are designed for wall mounting...other ratings for floor or platform mountings.

Available for high voltages of 120 x 240, 240 x 480, 480 and 600 volts to 120/240 volts single-phase, and 480 and 600 volts to 208Y/120 volts three-phase.

ELECTRIC MOTORS TRANSFORMERS INDUSTRIAL BRAKES AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIG

WTAG-3

how good should power cable be ... for dielectric strength?

At CIRCLE, the point is not how well specifications are metbut rather how far they can be exceeded! Take, for example, the well-known "double voltage test" as required by IPCEA-NEMA.

### **IPCEA-NEMA Performance Requirements**

"6.5.3 After the sample has been immersed for at least one hour, it shall withstand for 5 minutes a test voltage which is twice the test voltage given in Table 12."

"6.5.4 . . . starting with the voltage at which the test described in 6.5.3 was made, the voltage shall be raised in steps of approximately 20 per cent of the immediately preceding voltage until failure occurs, the voltage to be kept constant at each step for 5 mintues."

### "Circlesheath® Type RR Power Cable Performance"

The following table describes the performance of three samples of Circle butyl-insulated Type RR power cable.

CABLE	RATED VOLTAGE	DOUBLE AC TEST VOLTAGE	CIRCLE B'KDN VOLTAGE	MAXIMUM STRESS IN VOLTS PER MIL
2 AWG	5KV	28KV	48.3KV	454
1/0 AWG	5KV	28KV	40.3KV	356
500 MCM	5KV	31KV	44.6KV	307

A frequent sight at Circle is the checking of extruder operation by laboratory technicians. They are concerned with seeing that the quality they build into a cable in the lab is realized on the production line.



A Circle power cable, subjected for over two years to a 250% overload of rated voltage in a test still in process, continues to meet all specified requirements.

Turning out high-reliability power cable requires expert knowledge of compounds, absolute quality control—and men who know enough to produce the very best. Next time you specify power cable, ask for Circle—there's no finer made.



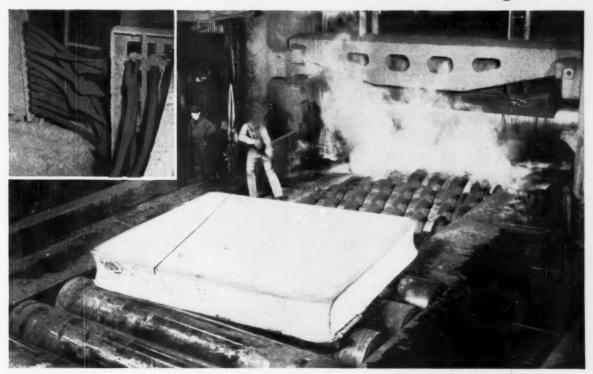
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a subsidiary of

CERRO DE PASCO CORPORATION

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### Cable That Won't Quit



### SILASTIC<sup>®</sup>

### survives torture... keeps production going

These photos, and the story behind them, provide an idea of the extraordinary service you can expect from cable insulated with Silastic, the Dow Corning silicone rubber.

The place: Lukens Steel Company. The installation: Exposed feeder cable for a 200 hp motor that powers America's largest plate rolling mill.

The mill operates around the clock, seven days a week . . . meaning the cable insulation is continuously subjected to some of the worst conditions imaginable: heat from the red-hot steel only a few feet away; hot "scale" off the steel; dripping grease; the salt used for cleaning the mill bed; and plenty of moisture.

No wonder it was necessary to shut down this mill at least once a year to service the cable . . . that is, until 1955 when a feeder cable insulated with Silastic was installed. Since then, there hasn't been a moment's downtime (or any lost production) due to cable service . . . for there just hasn't been any cable failure!

Could performance like this help whittle *your* annual maintenance bill . . . and keep production in high gear? What are your requirements for an insulation that increases cable life in almost any application and performs



Cable size: 500 MCM. Operates at 250 volts.

reliably despite such rough operating environments as in this installation? Leading manufacturers now offer power cable, control cable, hookup wire, fixture wire and building wire with insulation of Silastic. The latter two, of course, meet accepted UL standards. Want a list of these suppliers? Just write Dept. 3905a.

If you consider all the properties of a silicone rubber, you'll specify Silastic.



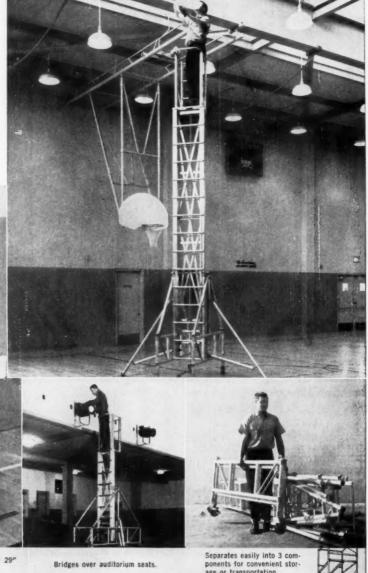
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BOYS



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Rated 2300 to 4600 volts for a-c motors up to 3000 hp.

Snap-action shutters to isolate high voltage ... another revolutionary design feature in new General Electric Limitamp control . . . and just part of the built-in protection which makes it a really safe motor control!

With General Electric's safety shutters, the operator is protected from high voltage. Before gaining access to the high-voltage compartment, the operating handle must be turned to the "OPEN" position. This action automatically causes the fuse shelf to withdraw . . . breaking high-voltage connections as the shutters drop to isolate the exposed bus terminals. Then-and only then-mechanical linkage releases the highvoltage compartment door.

When the door is opened, the operator makes three visual checks to assure himself that all high voltage has been isolated: 1)

Fuses are grounded against clips connected to the contactor frame; 2) Shutters are closed; 3) The position indicator by the operating handle shows "OPEN."

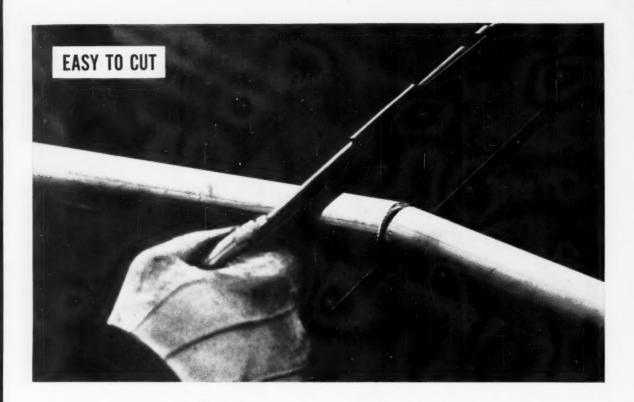
All other access to high voltage is blocked by metal barriers. The result: New Limitamp control is the safest, simplest motor control available.

Ask your G-E Apparatus Sales Engineer or Agent about other operation, performance, maintenance and installation features of Limitamp control. Or, write Sect. 783-13, General Electric Co., Schenectady, N. Y., for Bulletin GEA-6893. Industry Control Department, Salem, Virginia.

Progress Is Our Most Important Product

GENERAL ELECTRIC

\* Reg. Trade-mark of General Electric Company



# Reynolds Aluminum Rigid Conduit REDUCES INSTALLATION COSTS

Reynolds Aluminum Rigid Conduit can be cut quickly and easily with an ordinary hacksaw or power saw.' Thread-cutting is easy and standard cutting lubricants are used. One of the easiest to work of all metals, aluminum bends and forms simply and accurately. This is important when making saddle bends and in final adjustments at the junction boxes. And, because aluminum is lightweight—about one-third the weight of conventional conduit—

handling and installation are easier, and costs are lower.

Aluminum conduit resists corrosion from weather and most industrial atmospheres. Non-magnetic, it often permits longer conduit runs or smaller conductors.

For complete information and names of Reynolds Aluminum Rigid Conduit Distributors, call your Reynolds Sales Office or write Reynolds Metals Company, Box 2346-ET, Richmond 18, Va.









Watch Reynolds TV shows "ADVENTURES IN PARADISE", "BOURBON STREET BEAT" and "ALL STAR GOLF"—ABC-TV

Type CC2

on your next bill of materials-

see your

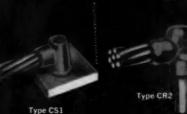
### BURNDY DISTRIBUTOR

for all of these connections made with



Type CS3









Type CR1

welds a permanent electrical connection easily and economically to any copper conductor or steel structure



Weld anywhere with light-weight THERMOWELD. Self-contained, needs no external source of power.

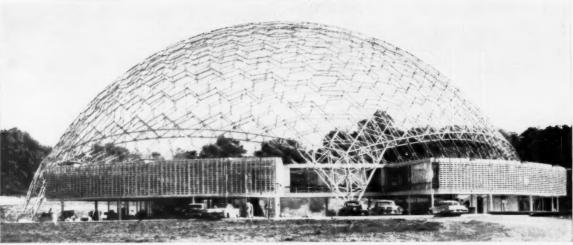


Pour powder into mold, tap. Starting powder won't mix with welding powder, as-sures positive firing.



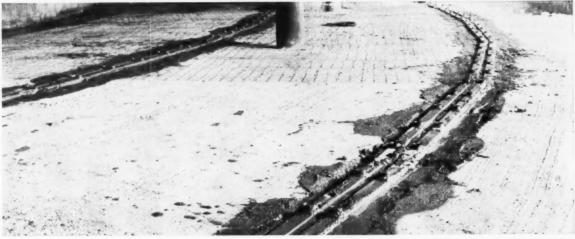
Close cover, ignite with flint gun. THERMOWELD forms liquid copper which fuses conductors into solid mass.

NORWALK, CONNECT. . BICC-BURNDY Ltd., Lancs., England . In Continental Europe: Antwerp, Belgium . TORONTO, CANADA



Ultramodern ASM headquarters at Metals Park, Novelty, Ohio demonstrates geodesic dome construction. Architects: John Terence Kelly, Cleveland, Ohio; General Contractor-Engineering: Gillmore-Olson Co., Cleveland, Ohio; Electrical Engineers (Plans & Specifications): John Paul Jones, Cary & Millar, Cleveland, Ohio; Electrical Sub-Contractor: Doan Electric Co., Cleveland, Ohio.

# Nepcoduct fits the job perfectly at ASM's New Geodesic Dome Headquarters



Continuous curve of building posed unusual problem in installing underfloor raceways.

To provide complete electrical flexibility, underfloor raceways were specified for American Society for Metals' ultramodern National Headquarters building at Novelty, Ohio. But they had to conform to the continuous curve of the semi-circular building. "Nepcoduct" fit the job perfectly without the use of elbows or special fittings—which meant economical installation. National Electric's "Nepcoduct" Under-

floor Raceway was the up-to-the-minute answer to a very new problem in electrical construction.

"Nepcoduct" Underfloor Raceways are but one of a complete line of modern underfloor and surface electrical distribution systems available from National Electric. For complete details, write to National Electric Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pa.

NATIONAL ELECTRIC DIVISION



H. K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

### "ADVANCE" FLUORESCENT SAVE OUR COMPANY KEEP OUR CUSTOMERS

LAMP BALLASTS
MONEY AND
HAPPY"



"Fluorescent Lighting Units utilizing efficient, cool operating ballasts require a minimum of service calls that are so costly to us and such an inconvenience to our customers. Quality ADVANCE FLUORESCENT LAMP BALLASTS save our company money and keep our customers happy".

To avoid expensive call-backs and costly down-time for your customers, always demand ADVANCE dependable Fluorescent Lamp ballasts. Their efficiency and performance is proved in millions of lighting units. They are the choice of the nation's leading Original Lighting Equipment Manufacturers and America's foremost Electrical Contractors. Reputations are built and maintained on ADVANCE Fluorescent Lamp Ballasts . . . truly, "The Heart of the Lighting Industry".

"The Heart of the Lighting Industry"





Manufactured in Canada by: Advance Transformer Co., Ltd. 5780 Pare Street, Montreal, Quebec, Canada

# another major

"PLAY BALL" will echo through Candlestick Park, new home of the San Francisco Giants, during the 1960 National League baseball season. Hatfield wire and cable has been used extensively for field lighting and other electrical services, in this newest, most modern ball park.

THE MOST UP-TO-DATE FACILITIES for the production of rubber insulated wire and cable are now in production at Linden, New Jersey.

Hatfield's new automated Linden complex also includes a new copper rod mill. Adding the plastic insulated wire and cable facilities at Hillside, N. J., Hatfield now has more than 600,000 square feet of production space in operation.

General Contractor, CHAS. 1. HARNEY
Construction Management,
ACCDONALD, YOUNG and NELSON, INC.
Architect, JOHN S. BOLLES
Consulting Engineer, LYLE E. PATTON
Electrical Contractor, BRAYER ELECTRIC



ATFIELD WIRE & CABLE

# league job by

kinds of requirements and come through with a winning performance every time. Because Hatfield's record ranks right up there with the all-time, all-weather, long-lasting greats in the wire and cable field, it is understandable why Hatfield products were specified for Candlestick Park — the new home of the San Francisco Giants. Few can match Hatfield's performance record, because Hatfield consistently "touches all bases". First... prompt, efficient service; Second... rapid delivery; Third... careful adherence to specifications; scoring every time... a complete line of plastic and rubber-covered wire and cable for construction, utilities and general industry. If you want the best, put Hatfield on your team.

HATFIELD PRODUCTS ARE SOLD EXCLUSIVELY THROUGH LEADING ELECTRICAL DISTRIBUTORS



DIVISION OF CONTINENTAL COPPER & STEEL INDUSTRIES, INCORPORATED PLANTS-HILLSIDE, UNION, LINDEN . EXECUTIVE OFFICES-HILLSIDE, N. J.





In this huge communications plant, over 7,000 fluorescent fixtures were hung by means of UNISTRUT raceway channels and fittings without precision layouts.

THE BIGGER THE JOB

### the more you save with UNISTRUT, framing!



EASE of on-the-job fabrication on projects like this is one reason leading utilities and engineering firms standardize on UNISTRUT framing.

Your next electrical installation may not be as big or complex as this 35acre Automatic Electric plant at Northlake, Illinois (above). But the facts on this big job show how savings multiply when you use UNISTRUT framing.

### No precision layouts!

• 18 miles of UNISTRUT framing supports the entire electrical system from point of entry of the main 4160 volt power cables to outlets at work benches. And no costly, detailed pre-designing was needed!

### No pre-fabricating!

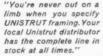
With UNISTRUT channels and fittings, workmen can do precision work quickly on the job. Hundreds of standard UNISTRUT fittings make special" jobs routine. Most alterations due to changes are done using only a wrench.

### Simplified ordering and handling of material!

· Contractors can stockpile UNISTRUT channels and fittings on the site, use them as needed anywhere in the system.

Get the whole story on how the patented UNISTRUT framing system saves on electrical installations. Phone or write for complete information.

### Mr. Strut says: 'You're never out on a



Pioneer in Adjustable Metal Framing

### UNISTRUT PRODUCTS COMPANY

GENERAL OFFICES: 941 West Washington Boulevard, Chicago, Illinois Telephone: MOnroe 6-2665 Teletype: CG-1329

Stocking distributors in all principal cities of the U.S. and Canada. Exported throughout the world.

### INTRODUCING



### **FASTENERS**

for the electrical construction industry HANG IT FASTER, FIRMER—AT LESS COST

### ROD HANGER CLAMP



For suspending 1/4" or 3/6" rod, plain or threaded, #8 or #9 wire from beams, joists or flanges. Clamps for 1/4 inch rod and under adapt to beam flanges 1/6 to 3/6 inch thick. 3/6 inch clamp will fit 1/8 to 1/2 inch beam flanges. Hammer required.



### CHANNEL CLAMP



Used for suspending 1½ inch channel from ¼ inch rod, ½ inch rod, and #8 wire. Provides instant, accurate alignment prior to channel installation. Designed to accommodate channel with a ½ inch to % inch flange width. No tools required.



### CONDUIT CLAMP



For rigid and positive holding of 1/2 inch, 3/4 inch and 1 inch O. D. thin wall conduit. This clamp provides ease of application with secure holding for pattern runs both vertical and horizontal. Screwdriver required.



### HOLD-DOWN CLIP



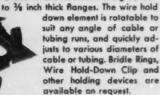
For use as intermediate hold-down of ½ inch, ¾ inch, 1 inch O. D. thin wall conduit between rigid support clamps. No tools required.



### CABLE AND TUBING CLIP

Wire Hold-Down Clip (illustrated) furnished and priced separately.

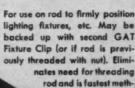
one size will snap securely in position to beams and columns having 1/8 inch







### FIXTURE CLIP









LOWERS "IN PLACE FASTENING COST". The GAT fasteners have completely revolutionized the slow conventional methods of fastening from lathing channel, fluorescent flutures, conduit, tubing, etc. These ingenious clamps do in seconds what takes minutes with other methods.













FASTENER PRODUCTS DIV.

Erico Products, Inc.

### NOW! Fuses that...

Safely interrupt fault currents up to 200,000 amperes...

Limit fault current to very low values

Hold 500% load for minimum of ten seconds

Buss Low Peak fuses can completely revolutionize the protection of the entire electrical system.

Protect Mains, Feeders, Branch Circuits, Motors, Controllers, Switches—no matter whether the fault current is 1,000 amperes, 25,000, 100,000—or as high as 200,000 amperes.

Reduce stresses and prevent damage to Panel-boards, Switches, Motor Controllers other circuit components—because let-thru fault currents are limited to exceptionally low values.

Prevent work stoppages, lights out, waste of time and money—because long time-lag keeps them from opening needlessly on motor starting currents or other harmless overloads.

Permit increasing interrupting capacity and current limitation on present system at minimum cost. Before designing a new installation— or modernizing old installations—

GET ALL THE FACTS



Knowledge without action is of little value—but ACTION NOW may save you money—increase operating efficiency and reduce electrical hazards to a minimum.

BUSS LOW-PEAK fuses fit standard Switches and Panelboards and are available in N.E.C. sizes from 15 to 600 amperes in both 250 and 600 volt ranges.

Write for BUSS LOW-PEAK Bulletin Now...or use coupon.

Bussmann Mfg. Division McGraw-Edison Co. St. Louis 7, Mo.

### BUSS Low-Peak **FUSES** SHORT-CIRCUIT LIMITING ELEMENT TIME-LAG ELEMENT Bussmann Mfg. Division, McGraw-Edison Co. University at Jefferson, St. Louis 7, Mo. Please send BUSS Low-Peak Fuse Bulletin LPS.

Address.

ECM-560



### RAPID REFERENCE CHART

SERIES	OPERATION	SWITCH	VOLTAGE	AMPS.	INTERMATIC QUALITY FEATURE	
T 100	1 to 12 on-off per day	SPST DPST SPDT	125/250 volts	35	Standard ON-OFF switch.	
T 170	1 to 12 on-off per day	SPST DPST SPDT	125/250 volts	35	Same as above, plus skips opera- tion on selected days, automatically.	
T 180	1 to 12 on-off per day	SPST SPDT	125/250 volts	35	Each on-off period independently adjustable from 5 to 60 minutes.	
T 960	1 to 96 on-off per day	SPST SPDT	125/250 volts	20/15	Each on-off period in 15 minute units. Trippers permanently attached to dial.	
C 8300	1 to 12 on-off per 12 minutes	SPST	125 volts	15	Timings from 10 seconds to 11 minute, 50 second periods.	
T 500-R	1 to 12 on-off per day	SPST DPST	125/250 volts	55	Heavy duty standard ON-OFF switch. Up to 27,500 watts. Also available with "SKIPPER" feature.	
T-1100	1 on -off operation per day	SPST	125 voits	15	Flush wall mounted standard ON-OFF switch to central circuits in house or store. (LAMP • LYTER)	



### THERE'S AN Ontermatic. FOR EVERY NEED!

Residential and Commercial Lighting Control • Air Conditioning Heating • Industrial Uses • Farm and Poultry Lighting • Signs Signal Bells, Buzzers, and Lights • Outdoor Installations Flush Mountings

Write for Bulletin 50-B

### **NEW! LAMP · LYTER**

the light switch with an electric brain!



FOR HOME AND STORES flush mounts, controls post lights, store lights, signs, other selected circuits.



### INTERNATIONAL REGISTER COMPANY

CHICAGO: 2624 West Washington Blvd. . NEW York: 41-14 24th St., Long Island City

### Naugatuck KRALASTIC®



### Here's why large East Coast utility chooses KRALASTIC conduit

Ease of use Unlike the wood moldings and rigid type of conduit normally used, KRALASTIC conduit can be flexed to follow irregularities of pole or mounted equipment, saving many needless breaks or fittings. It is simply and quickly cut to length with a hacksaw, securely stapled in place. And conduit of KRALASTIC is easy to handle because it's lighter than aluminum.

Protection KRALASTIC is an excellent electrical insulator. It is extremely tough, even in thin-wall sections, in this case allowing reduction in conduit diameter from the previously used 2" to 1". It not only requires less material, but is less bulky and easier for linemen to climb around. KRALASTIC's unusual toughness protects against accidental damage from linemen as well as storms and other causes. And, of course, KRALASTIC can't rust, rot, or corrode, withstands weather at its worst.

Economy Because extruded KRALASTIC conduit is relatively inexpensive, unusually easy to work with, and extremely durable, it provides important savings in all areas.

What's your line? If it involves piping or conduit, it might well call for KRALASTIC... the original ABS plastic that has proved its superiorities in nearly 10,000 miles of piping installations, in other products from baby combs to football helmets. Better look into KRALASTIC now.



### United States Rubber

Naugatuck Chemical Division NAUGATUCK, CONNECTICUT

KRALASTIC RUBBER-RESINS . MARVINOL VINYLS . VIBRIN POLYESTERS

Akron · Boston · Chicago · Gastonia · Los Angeles · Memphis · New York · Phila · CANADA: Naugatuck Chemicals · Elmira, Ont. · Cable: Rubexport, N.Y.

### AVAILABLE IN STOCK AT YOUR DISTRIBUTORS

Something special in lighting
THE CLASSIC

Finest in classroom and general commercial lighting

Versateer

Today's mort popular and most imitated commercial lighting fixture. Available with Benjamin's own 45° plastic louver or the exclusive new L-120 lens. Features a new "stocking pack," making every

fixture adaptable for individual or continuous mounting. Adaptable to almost any commercial lighting application, this simplified quality unit offers easy wiring and universal adaptability.



Benjamin-designed to give you more features and lighting qualities than any similar unit available today. 35° x 25° shielding in two or four lamp design.

Simplified butt mounting feature, permits continuous row installation, assures perfect alignment. For utmost value, Versateer cannot be equalled.

For those tough-to-light corridors

For cheerful completely glareless light

the Benjamin





SWIVEL STEM SUSPENSION

This is the perfect companion for all the fixtures shown above—the new unit-packed stem suspension. Boasts a modern sliding clamp hanger and an exclusive built-in leveling device; this 18" stem suspension is packed two to a carton, complete with all parts and components.

Single-lamp plastic enclosed fluorescent fixture, designed to provide low-cost, glare-free illumination for aisles, stairways, washrooms, waiting rooms, book stacks, other similar locations. A dependable quality unit with complete lamp shielding, easily cleaned and maintained.

**B** Unit-packed simplicity combined with streamlined styling and 2 high lighting efficiency are outstanding features of this popular plastic enclosed fluorescent fixture. A two-lamp unit, it affords economical, glareless lighting for stores, offices, other commercial applications. Polystyrene plastic cover snaps into channel for rigid, trouble-free installation.

# Now your four mostwanted fixtures are just a phone call away!

Henjamin Sisteilete

makes these fixtures available now from his stock

Now—your Benjamin distributor can deliver these four most popular commercial lighting fixtures...right when you need them! Because these four Benjamin units lead the field in popular appeal, he maintains a constant stock...to fill your orders as you place them. Check these favorite fix-

tures now -you'll find them ideal for remodeling or modernization, as well as new construction. Notice that each gives you complete flexibility—can be installed singly or in continuous lines; suspended or surface mounted. They're only a phone call away... dial your Benjamin distributor now!



GIVEAWAY
LITERATURE
COMPLETE
WITH ALL THE FACTS
AND FEATURES
INCLUDES SIMPLIFIED

Your Benjamin distributor will provide you with free quantities of this 6-page Benjamin folder. Shows, describes all four fixtures—features a short cut lighting estimator for any lighting job. Get it...let it sell for you!

ASK YOUR BENJAMIN DISTRIBUTOR to show you how the "basic four" can produce more commercial sales for you!



DIVISION Des Plaines, Ill.

THOMAS INDUSTRIES INC.

BENJAMIN . MOE LIGHT . STAR LIGHT . ENCHANTE . SAN MARINO

### O.Z. ELECTRICAL MANUFACTURING CO.

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CABLE SUPPORTS



SPLIT



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WEATHERTIGHT SUBMERSIBLE TYPE



TERMINATING POTHEADS



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TERMINATORS



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TWO-WAY CONNECTORS



SERVICE TAP



COMBINATION TEE AND PARALLEL CONNECTORS

### POWER CONNECTORS



T-CONNECTORS, TUBE



BUS BAR

# GROUND CONNECTORS

CABLE TO PIPE OR ROD 90° OR PARALLEL



CABLE TO

They're O. K. if They're O. Z.

# NOW . . . REMOTE CONTROL FOR WESTINGHOUSE TYPES E, EH AND F BREAKERS

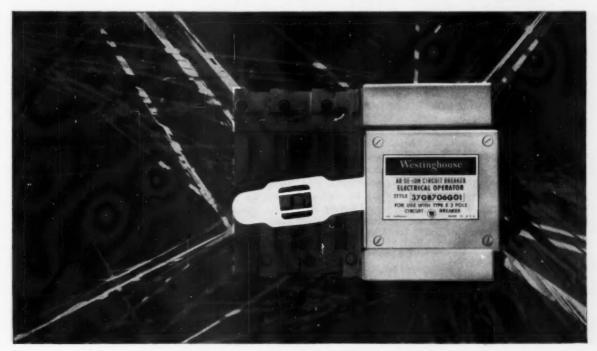
This magnetically operated unit turns your types E, EH and F breakers into a remotely controlled switch for—service entry panels—control panels—billboard, railroad yard, parking lot and industrial lighting systems. Use it as a remote switch for battery chargers—engine generators—you can think of a score of other uses.

□ This new Westinghouse Electric Operator is the same size and fits the same space as the breaker it controls. Its action is strong and positive, with the advantage of manual control when desired. In fact, this new electric operator does the same job for the smaller breakers that a motor operator does on the larger type breakers. What's more, the cost is much less. Electric operator works on 120, 240, 480 or 600 volts a-c; 125 volts d-c.

□ There's a 4-page, 2-color illustrated brochure available describing more about the Westinghouse Electric Operator. For your copy write: Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa.

J-30215

### YOU CAN BE SURE ... IF IT'S Westinghouse



ELECTRICAL CONSTRUCTION AND MAINTENANCE . . . MAY, 1960



Revere Outdoor Lighting makes driving and parking safe and easy at Eastpoint Shopping Center, Baltimore, Md. The well lighted parking lot makes the shopping center look more inviting. Architect:

Kenneth C. Miller; Consulting Mechanical Electrical Engineers: Whitman, Requardt & Associates; Electrical Contractor: Harry A. Goldberg Co.; Electric Wholesaler: Graybar Electric Co., Inc.

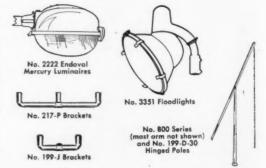
### Revere's complete line of matched equipment makes any outdoor lighting job easier

Any outdoor lighting problem is easier to solve with Revere equipment. The wide line, from one source, lets you select the exact combination of fixtures required to do the job best . . . simplifies ordering and assures on-schedule delivery, too.

At Eastpoint Shopping Center (above), Revere Endoval Mercury Luminaires, mounted on Revere hinged poles, illuminate driving lanes. Parking area lighting is provided by Revere floodlights with 400-watt EH-1 mercury lamps. Floodlights are mounted two or three to a Revere hinged pole, with pole spacing 150 ft. Ballasts are in manholes between poles. Average maintained footcandles 1.1.

Installation of equipment at Eastpoint was easier because Revere components are *matched* for strength, balance, and perfect fit . . . and for peak lighting efficiency. Write for a Revere outdoor lighting equipment catalog. The complete, matched line makes solving any outdoor lighting problem easier.

Revere components used to light shopping center





### OUTDOOR LIGHTING

Revere Electric Mfg. Co. • 7420 Lehigh Avenue • Chicago 48, Illinois (In suburban Niles)
Long-Distance Phone: NI les 7-6060 • Chicago Phone: SPring 4-1200 • Telegrams: WUX Niles
In Canada: Curtis Lighting, Ltd., Leaside, Toronto, Ontario









Precause of the many uses of electricity in the kitchen requiring individual-equipment circuits, it is recommended that the electric service equipment be located near or on a kitchen wall to minimize installation and wiring costs."

AMERICAN STANDARD REQUIREMENTS FOR RESIDENTIAL WIRING ASA C91.1—1958; UDC 621.315.3:728; AIA File No. 31-C-61

The modern "housepower" protection you are proud to make convenient...

Contractors know most people prefer the protection circuit breakers provide for wiring. The majority of new homes being built have breaker panels.

Contractors also know most people prefer to make such protection convenient. New home plans should put the breakers in or near the kitchen where they belong. Frequently, however, people try to hide their breaker panel because of its appearance. When you hide anything, you have to hunt it when you need it . . . and that's not the way to get convenience.

Cutler-Hammer has done something about this in designing the new Cutler-Hammer Safetybreaker! It's appliance-styled to match the finest kitchen equipment. Its muted sandalwood finish is just what women prefer. This new Safetybreaker is truly the modern "housepower" protection you are proud to make convenient.

See the excerpt above from American Standard Requirements For Residential Wiring sponsored by the "Industry Committee on Interior Wiring Design" with the approval

of its participating organizations.

American Home Lighting Institute

American Institute of Electrical Engineers

American Society of Agricultural Engineers

Edison Electric Institute

**Illuminating Engineering Society** 

International Association of Electrical Inspectors

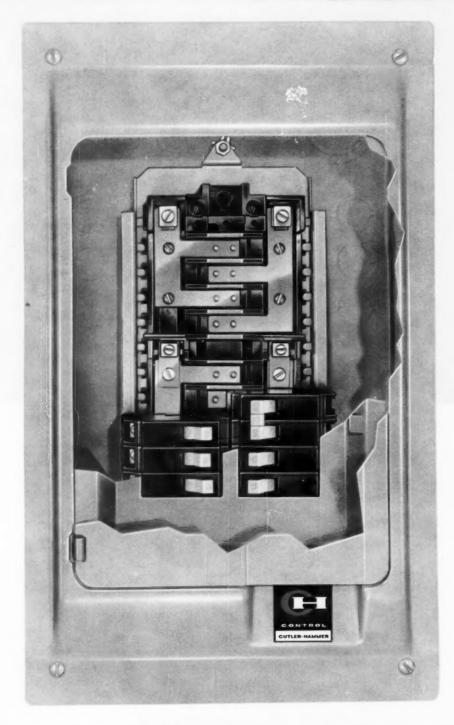
National Association of Electrical Distributors

National Association of Home Builders

**National Electrical Contractors Association** 

National Electrical Manufacturers Association

Radio, Electronics and Television Manufacturers Association



Easiest to install . . . a C-H Safetybreaker saves you time and effort on every job.

- Three point keyhole mounting assures perfect case alignment.
- Plenty of wiring room . . . no wire guides to skin your knuckles.
- Box type lugs on all terminals end wire pretzel bending.
- Power terminals accept both copper and aluminum cable . . . no extra cost.
- No chance for error, bus design assures proper phase balancing.
- Solid bus bars eliminate troublesome current-carrying
- Sure-grip Safetybreakers snap into position . . . your screwdriver never need touch the hot side of the line.
- Front adjusting leveling device provides a firm nonvibrating base for the bus mechanism.
- Twist-out louvers always maintain a neat appearance

   . . . no thin dividers to complicate blank removal or cover-to-breaker alignment.

# The new Cutler-Hammer Safetybreaker is as new in its features as in its appearance. Comparison proves its superiority. See it now!

New electronically calibrated, fast-trip magnetic-thermal Safetybreakers . . . provides positive circuit protection from direct shorts and build-up overloads.

Contrasting handle flags the overloaded circuit. No in-between trip point. A C-H Safetybreaker is either on or off . . . just like a light switch.

# Cutler-Hammer Safetybreakers offer non-interchangeability provision



The all new Safetybreaker is your best buy for every job . . . yes, even those that call for non-interchangeable circuit breakers. The non-interchangeability feature of the C-H Safetybreaker is an integral part of its all-new design . . . not a mere design modification. There are no extra parts or adapters to be added each time a breaker is installed . . . no mounting pins or tabs to be removed . . . no chance for errors—you can't make a mistake . . . no additional expense to you during installation.

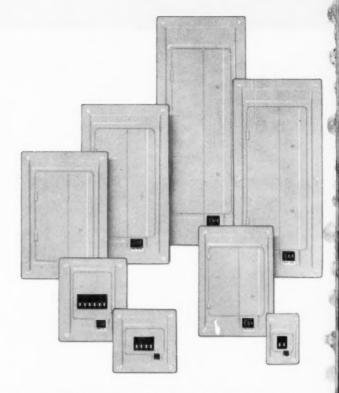
... for extra value at no extra cost

# Install the new Cutler-Hammer Safetybreaker









Now available in every needed size and type of service entrance and load center; Cutler-Hammer Safetybreakers range in size from 2 to 42 circuits; 40 to 200 ampere capacity; series, parallel, and split-bus construction; single phase 3 wire and three phase 4 wire.

Write today for the new "Safetybreaker Selection Guide". You'll find it most interesting and informative. Ask for Publication ED125-J241. Cutler-Hammer Inc., Milwaukee 1, Wisconsin



## CUTLER HAMMER

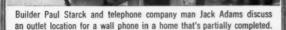
Cutler-Hammer Inc., Milwaukee, Wis. • Division: Airborne Instruments Laboratory. • Subsidiary: Cutler-Hammer International, C. A.

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

This modern, telephone-planned Starck home won an American Home Magazine citation.







Your local Telephone Business Office will gladly help you with telephone planning for your homes. For details on home telephone installations, see Sweet's Light Construction File, 11c/Be. For commercial installations, Sweet's Architectural File, 34a/Be.

BELL TELEPHONE SYSTEM



# "Concealed telephone wiring doesn't <u>have</u> to be sold. It has already sold itself."

-- says Paul F. Starck, Math Starck & Sons, Inc., Milwaukee, Wis.

Math Starck & Sons, Inc., was one of the first builders in Milwaukee to offer home buyers concealed telephone wiring. The firm has built about 150 custom homes since 1946—and, since 1955, nearly all of them have featured this modern convenience.

"This is a family business," says Paul Starck, field and office superintendent of the firm, "and my dad, two brothers, a brother-in-law and I are all sold on concealed wiring. It helps show people our homes are quality-built. They appreciate having built-in outlets for future telephones—and the fact that wiring is neatly hidden inside the walls.

"It's definitely a good investment for us. We figure it costs us less than onetenth of one per cent of the cost of a house to offer it—and it really pays off in sales appeal, really helps us sell our homes.

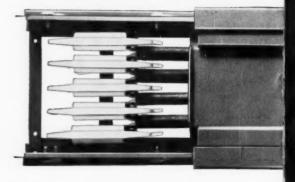
"Concealed telephone wiring doesn't have to be sold. It has already sold itself."

# INTRODUCING NEW



The safest, fastest-to-install

plug-in duct ever designed!



Now BullDog, the originators of Bus Duct systems, gives you new safety for plant personnel plus new installation speed and economy with new XL BUStribution duct! Completely Butyl covered aluminum bus bars give true dead-front construction. Crews can now install more duct in a day than ever before. Superior engineering provides low voltage drop . . . down to half that of other plug-in duct systems . . . plus unexcelled short circuit rating. BullDog gives you completely engineered fittings. You can get everything you need from a single source -your local BullDog distributor. Call him-he'll give you a demonstration of all the XL safety and installation features.

Keyed bus ends align themselves positively, instantly, without fumbling or wasted time. You can position sections as fast as you can handle them!

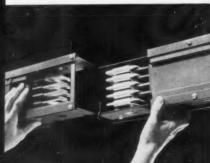


This one integral bolt locks POSITIVELY... holds keyed bus ends under a ton of pressure The fully insulated bolt spins tight fast Joints stay locked!

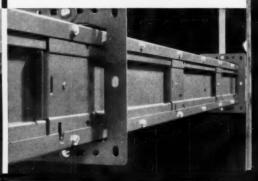


#### ECONOMICAL INSTALLATION

You need only half as many hangers as usual. Ten-foot supporting spans cut number of hangers and the time needed to install them by 50%.



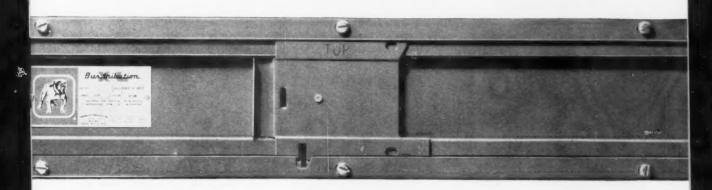




# BULLDOG









# The new XL SAFETY-PLUG is faster, safer to use than any other plug!

XL Safety-Plug has new, simplified design. You can plug-in on XL duct in seconds. It has safety features not found on any other plug. Plugs are available which prevent installation or removal when plug handle is in the "on" position. You can plug in from either side of the duct, in all duct sizes from 225 through 1000 amps. You can use all plug-in openings at the same time, if desired.

When you see your BullDog distributor about XL duct, examine the Safety-Plug he has on display, too. Here's an electrical team you can depend on to do the job better in every way!



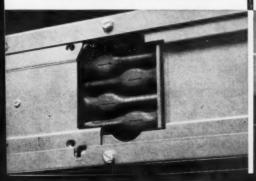
BULLDOG ELECTRIC PRODUCTS DIVISION

BOX 177 . DETROIT 32, MICHIGAN

In Canada: 80 Clayson Rd., Toronto 15, Ont. Export Division: 13 East 40th St., New York 16, N.Y.

#### DEAD-FRONT SAFETY

Each bus bar has full-length Butyl insulation, even in bus plug openings. XL BUStribution Duct is the world's safest duct to plug into, to work around.



#### PERSONNEL SAFETY

Safety door covers the opening . . . slides back when safety interlock finger is in position. Plug cannot be removed or installed when safety door is open.

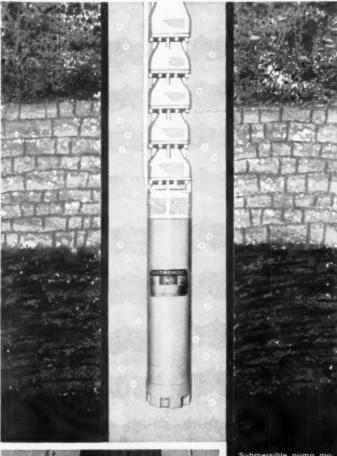


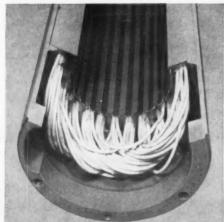
#### EQUIPMENT SAFETY

SAFETY PLUGS cannot be installed or removed when in the "on" position... exclusive design positively protects against arcing, asfeguards equipment.



## B.F.Goodrich Chemical raw materials





Submersible pump motors are manufactured by Westinghouse Electric Corporation, Sunnyvale, California, using waterproof wire insulation made of Geon by Sequoia Wire & Cable Company, Redwood City, California. B. F. Goodrich Chemical Company supplies the Geon vinyl.

# Problem of motor submersion solved with Geon insulation

This new motor operates under water using the water itself as a lubricant. Since the housing is water filled and "breathes" well water, its operation depends on the insulation of Geon.

Geon met tough requirements. The manufacturer says that many materials were tested to find one that would stay waterproof indefinitely and also have enough mechanical strength to stand up under the winding process and under flexing imposed in starting.

A test motor was submerged under 400 feet of head for six months and subjected to frequent starting and operation. At the end of the test, the Geon insulation showed no signs of deterioration. Geon also eliminates need for thick and dense coatings over end turns—eliminating a cause of trapped heat and premature failure.

Here's another example of the way that Geon vinyls open new markets, or improve present applications. For more information, write Dept. GY-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.



B.F.Goodrich Chemical Company a division of The B.F.Goodrich Company



GEON vinyls . HYCAR rubber and latex . GOOD-RITE chemicals and plasticizers



# "We Hooked it Up and Walked Away"

In the electrical signaling and communication industry this expression, coming from an electrical contractor, is the highest recommendation he can give of a manufacturer's equipment. It means "Well done! Your system installed easily and worked properly the first time. No rejects... no grounds or shorts... no trouble shooting, with all that means in running up the cost of a job. It worked like a charm!"

We're accustomed to hearing this expression quite frequently at Auth. Our equipment has always been designed to make installation easy. We give the contractor what he needs . . . wiring diagrams, equipment draw-



ings, installation and operating instructions. All material is thoroughly tested before shipment.



We... at Auth... do this not only because it comes naturally. We do it because every time a contractor says to us "We hooked it up and walked away," we know that he'll be coming back to us on the next job. That's good will.

Manufacturers of

ELECTRICAL SIGNALING,
TIME AND COMMUNICATION
SYSTEMS FOR HOSPITALS,
SCHOOLS, HOUSING,
INDUSTRY AND SHIPS

Sold in cooperation with the distributor

Auth Electric Company, Inc.

LONG ISLAND CITY 1, NEW YORK

ELECTRICAL CONSTRUCTION AND MAINTENANCE . . . MAY. 1960

If you just figure the cost of lamps you only know about 1/10th of the story!

# Only a Total Cost

What about cost of power?

What about his time?

What about cost of lamps?

# of Lighting analysis can show



· how you can really cut expenses

#### HOW TO FIGURE YOUR TOTAL COST OF LIGHTING (TCL)

(Calculations shown here are based on the average 7500-hour operating life of a standard Sylvania 40 CW lamp which requires 46 watts of power including ballast.)

			nal average er lamp	Put your costs here
1.	Net cost per lamp (at average discount of 35%)	) \$	.81	
2.	Power cost per lamp based on average industrial rate of 1.5¢ KWH (watts $\times$ 7500 hours $\div$ 1000 $=$ KWH)		5.18	
3.	Maintenance cost per lamp (one cleaning plus one replacement figured at average industry rate of \$3.00 per hour)		2.00	
	Total Cost of Lighting (TCL) per lamp	p	7.99	
	TCL for 100-lamp installation	n \$	799.00	
	(Note: If you use 100 Sylvania lamps, figure the 8% extra lighting value of 8 lamps over 100 ordinary lamps.*)		×.08	
	Saving through extra Sylvania lighting value®	\$	63.92	

\*These are the extra dollars you would have to spend per 100 ordinary lamps to get the equal lumen hours of light you get from Sylvania.

Sylvania is so sure savings will result from figuring this way, we'll even send our representative to show you how (or you can do it here - now!)

With cost of lamps amounting to only about 10% of your Total Cost of Lighting (TCL), why should Sylvania be so interested

in this new over-all way of figuring? Two good reasons:

First, because TCL best demonstrates the over-all superiority of Sylvania fluorescents.

Second, because we believe that just in figuring TCL you'll discover a number of new opportunities for shaving costs. And that's one of the things we like to help you do.

What is your TCL? Cost of lamps plus power plus maintenance. Add cost of fixtures, too, if you're remodeling.



WITH TCL ANALYZER, a Sylvania representative can figure in minutes plant affect Total Cost of Lighting. Our representative can help figure special conditions in your plant. With his Analyzer Kit, he can do it in minutes, give you a complete lighting analysis free.

He can also show you how and why, for every penny you spend for lamps, power and maintenance, you get more value with Sylvania.

And he'll show how Sylvania backs its claims to lowest TCL with an exclusive Light Insurance Policy. Guarantees Sylvania fluorescents will perform better in your own opinion than the brand you are now using-or your money back!

Call your Sylvania representative. Or write us: Sylvania Lighting Products, a Division of Sylvania Electric Products Inc., Dept. 15, 60 Boston St., Salem, Mass. In Canada: Sylvania Electric (Canada), Ltd., Box 2190, Station "O," Montreal 9.

EXCLUSIVE SYLVANIA LIGHT INSURANCE POLICY is your guarantee of lowest TCL - or your money back!

Subsidiary of GENERAL TELEPHONE & ELECTRONICS



STLVANIA





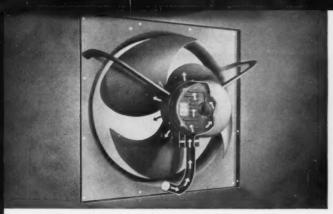
# The learned buyer of motor control centers

The circuit breakers hardly show on a modern motor control center. But they do the work. Get good circuit breakers and you get good protection . . . extra insurance of continuous electric power . . . lowest net cost. Get poor breakers and you invite trouble. What make can you buy most confidently? Motor control center builders prefer I-T-E over all other makes. Better value. Yet costs no more.

Write for the new bulletin on I-T-E molded case circuit breakers. I-T-E Circuit Breaker Company, Dept. SA, 1900 Hamilton Street, Philadelphia 30, Pa.



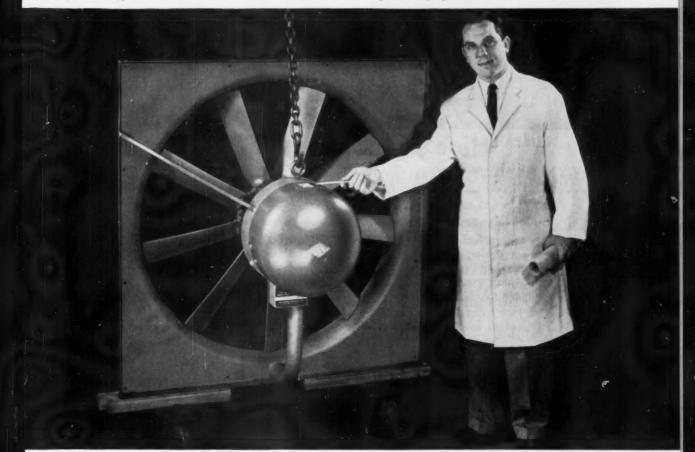
## I-T-E CIRCUIT BREAKER COMPANY



**Cool, Clean, Quiet.** Vent pipe sucks in outside air, *pressure-cools* permanently lubricated Ilg-built motors—designed to provide operating cost advantages of *open-type* motors plus the protection of *totally enclosed* types.



"Check-Out" Time. Every Ilg-built propeller fan wheel must pass rigid dynamic balancing "checks" before being directconnected to Ilg-built self-cooled, 3-phase or permanent splitcapacitor, single-phase motor.





Square Panel Propeller Fans move up to 37,550 CFM

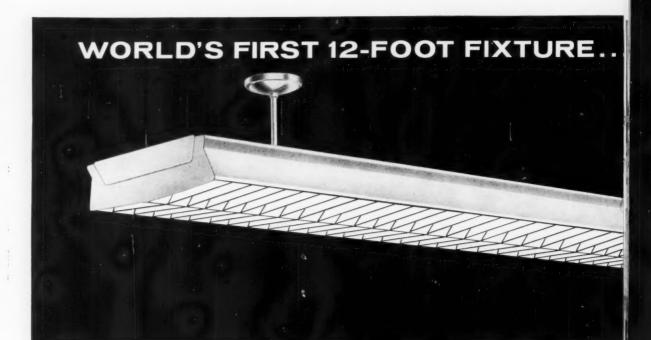
You're looking at the new Ilg Type PF square panel propeller fans. Note the sturdily constructed 14-gauge steel mounting panel; the deep-throated streamlined orifice that increases fan efficiency; the choice of fan wheels—airfoil design blades (either five or nine) for operating against higher static pressures, and Ilg's patented Type "Q" blades for super-quiet operation on ordinary requirements.

Choice of three sizes: 36-, 42- and 48-inch fan wheels. All fans feature Ilg self-cooled motors, direct-connected, permanently lubricated. And all bear the Ilg "One-Name-Plate" pledge of performance. Write for Bulletin DB1-106.



#### ILG ELECTRIC VENTILATING COMPANY

2879 No. Pulaski Road, Chicago 41, III.
Offices In 59 Principal Cities
Member of Air Moving and Conditioning Association Inc. (AMCA)



## Here's proof of installation savings...

#### Others talk about installation savings. Garcy guarantees them!

Our new 12-ft. fixture makes it possible. On 9 out of 10 sizable jobs we can actually offer a signed guarantee that, from the time ceiling hickeys are in place, total assembly and hanging time will not exceed  $1\frac{1}{2}$  man-hours per 24 ft. of fixture. If this time is exceeded on a job covered by our signed guarantee, excess time may be billed to us.

The guarantee figure is less than half of ordinary labor estimates for fixture installation. Even at that the chances are it will be halved again on the actual job. And this is top quality lighting. Efficient, well-shielded, low-brightness lighting that meets today's higher lighting standards for schools and offices.



Runs of any length joined and wired at work level.



Runs of any length raised to the ceiling as a single unit.

# GARCY SUPER SPEED-LINE • 45°×45° SHIELDING • ONE-PIECE SHIELD • FEWER HANGERS NEEDED (ONLY 3 PER 24 FT. ROW)

### ..a new and unique man-hour guarantee

#### Here's why Super Speed-Line savings can be guaranteed.

- 1. 12-foot fixtures mean less handling, fewer couplings, fewer splices. Only two fixtures per row in a typical classroom.
- 2. Stem spacing up to 12-ft. O.C. means fewer hangers, fewer supports. Only three stems for runs to 28 feet.
- 3. Work-level assembly means complete runs are joined before, not after, raising to the ceiling.
- Unit-hanging means complete runs are raised to the ceiling as a single unit.
   There's an absolute minimum of ladder time.

#### HOW TO GET A SUPER SPEED-LINE GUARANTEE

This advertisement is an offer to furnish a guarantee of labor time on jobs meeting certain reasonable conditions; it is not a guarantee in itself. The actual guarantee is a document rendered on an individual job basis, signed by an officer of Garcy Lighting and countersigned by the electrical contractor.

Send today for a facsimile copy of the guarantee and complete details on the Super Speed-Line system. Use the coupon for a prompt reply.

# GARCY LIGHTING

Division of Garden City Plating & Mfg. Co 2475 Elston Avenue, Chicago 47, III.

Please send details on the Super Speed-Line system and a facsimile copy of the Garcy Guarantee.

Name\_\_\_\_\_Title\_\_\_

Company\_\_\_\_

Street Address\_\_\_\_\_

City\_\_\_\_\_State\_\_\_\_



"G-E Remote-Control Wiring has saved money since the day it went into this building in 1953," says Mr. Donnelly, standing in front of 3-story, block-long office building, Menands, N. Y.

# "G-E Remote-Control Wiring saved us \$20,561 in this N.Y. Telephone building - on installation alone!"

... Mr. H. J. Donnelly, Supervising Electrical Engineer New York Telephone Company, Albany, N.Y.

"We compared General Electric Remote-Control with an ordinary switching system that would give us the kind of lighting control we wanted," says Mr. Donnelly. "We were surprised to find that, in addition to its other advantages, the G-E low-voltage system cost \$20,561 less to install!

"On top of the initial savings, we reduced our operating costs, because G-E master switching makes it easy for maintenance crews to turn On only those lights needed, rather than lighting up whole floors. Switches at convenient locations save our men extra steps, too.

"These savings were all in addition to the original reason we considered Remote-Control. That was extra safety in controlling the 480Y/277-volt power system we chose for its saving in branch circuit copper. Remote-Control relays in the ceiling control the 277-volt lighting circuits, so there's only a low, 24 volts at the switches. Of course, the lightweight, 24-volt switch wiring makes it easier to relocate office partitions, too. And the elimination of switch-loop voltage drops that can cut the life and efficiency of lamps, is still another feature."

General Electric would appreciate the opportunity of working with you on the design of a Remote-Control Wiring System tailored to fit your particular needs. Write Commercial Engineer, General Electric Company, Wiring Device Department, Providence 7, Rhode Island.



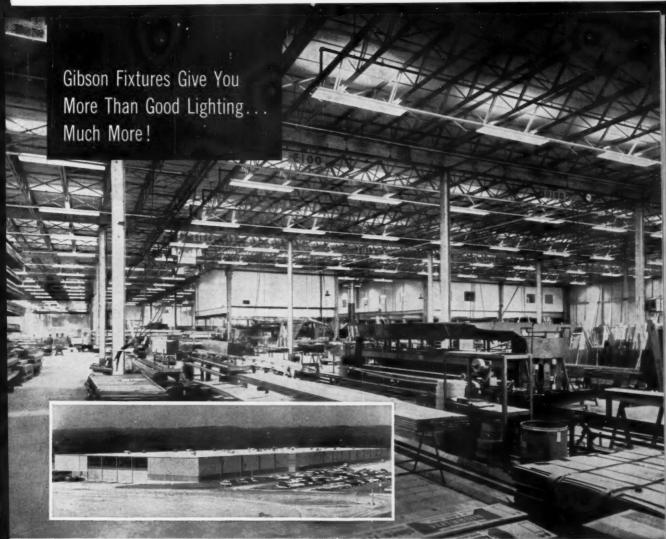
"Douse the lights you don't need!" is standard procedure for maintenance crew, in building from 5:00 to 11:00 p.m. G-E Remote-Control makes it easy.



G-E master selector switches at ends and center of each floor control lighting separately for each ½ floor. Building contains 2000 fluorescent lamps.

Progress Is Our Most Important Product





ARCHITECT, MASTIN & SUMMER; ELECTRICAL ENGINEERS AND CONTRACTORS, CLEVELAND ELECTRIC COMPANY; GENERAL CONTRACTOR, IRA H, HARDIN COMPANY

#### GIBSON "PLUG-IN" FIXTURES SIMPLIFY MAINTENANCE FOR AMERICAN ART METALS



American Art Metals Company, Atlanta, uses Gibson fixtures with Power Groove lamps throughout its new plant. "We particularly like the ease of maintaining these fixtures," says E. L. McNiff, general works manager. "When a conventional fixture needs servicing, an electrician may spend half an hour or more up on a ladder to do the job. This distracts production workers. But when one of our Gibson fixtures needs attention, it is simply unplugged and another 'pluggedin' in its place-in the time it takes a man to climb a ladder."

The exclusive "plug-in" feature of Gibson fixtures also offers substantial savings in installation costs and allows for re-spacing of fixtures and increasing lighting intensities any time without re-wiring.

Write for complete descriptive literature







Makers of THE FIXTURES THAT JUST



COMMERCIAL, TROFFERS, INDUSTRIAL

GIBSON MANUFACTURING COMPANY 1919 Piedmont Circle, N. E., Atlanta 9, Georgia Mr. Lester C. Breitzman, Assistant Fire Marshal, Bureau of Fire Prevention, Evanston, Illinois, says:

# "This automatic fire meets every requirement



Assistant Fire Marshal Breitzman at the central fire alarm panel, located just inside the main entrance. A fire in any of the three Washington National Buildings will sound an alarm here, and cause a light to flash, indicating the exact floor and building. Firemen can thus pinpoint the trouble-spot immediately.

# detection and alarm system of our safety code."



WASHINGTON NATIONAL INSURANCE
BUILDING, EVANSTON, ILLINOIS
Architect-Engineer: Graham Anderson,
Probst and White, Chicago
General Contractor: A. L. Jackson
Company, Chicago
Electrical Contractor:
Hyre Electric, Chicago
Mechanical Contractor:

Carrier Corp., Chicago

#### The Washington National Insurance Building is protected by a Honeywell system that detects fire and sounds an alarm in the building and at the Fire Department.

"This type of fire protection system is ideal for an insurance company," says Chief Breitzman. "Detectors located throughout the building will automatically detect a fire and ring alarms in the building and at our fire station. And it provides *continuous* protection. The 552 detectors installed here function as 552 watchmen, on 24-hour duty."

Chief Breitzman was consulted during the location of the automatic detectors in the Washington National Insurance Building. The building also has manual pull stations for double protection. Either will sound the alarm and indicate the location of the fire on a panel in the lobby and at the central control console in the Chief Engineer's office.

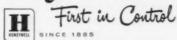
The system is so foolproof, it will trip the alarm even with a ground or a break in both wires of the detecting loop. A standby battery makes sure the alarm will go off even during a power interruption. The components of the system are listed by U.L. and backed by fast, efficient Honeywell service.

Honeywell's complete line of automatic fire detection and alarm systems will meet the most rigid fire safety codes. For additional information, call your nearby Honeywell office. Or write Honeywell, Dept. EC-5-76, Minneapolis 8, Minnesota.



Mr. Clifford Fohr, Second Vice-President of Washington National, and Marshal Breitzman discuss a fire detector in the main lobby. Breitzman explains that the detector can sense a fire as much as 25 feet away.

Honeywell







# New ORANGEBURG® G\*CONDUIT with Flush Coupling Attached!

With no separate couplings to handle or attach on the job, Orangeburg CA lays faster, costs less to install. Each long, light length has a flush coupling attached at one end and a standard 2° male taper at the other end, making installation a simple, one-step operation. And, since the coupling is attached, there are no coupling cartons to warehouse or carry to the job.

What's more, with the coupling flush to the conduit's outside wall, new CA is easy to stack, store and handle. The flush coupling also eliminates "staggered" joints in the trench. And that means real savings in cutting and tooling time. Like the hundreds of millions of feet of Orangeburg fibre

conduit in use since 1893, new CA has self-sealing joints and impermeable walls. Its smooth, 100% fibre raceway adds years to cable life.

New Orangeburg CA is available in 2", 3", 31/2", 4", 41/2" and 5" sizes. Orangeburg Standard and Nocrete Conduit, with separate sleeve couplings, are available as always. Write Dept. EC-50 for Catalog 52.

#### ORANGEBURG MANUFACTURING CO. Orangeburg, New York

Division of The Flintkote Company, Manufacturer FLINTKOTE of America's Broadest Line of Building Products



Orangeburg Fibre Conduit is distributed by Graybar Electric Co. and General Electric Supply Co. with branches and stocks in principal cities.

# NOW YOUR CUSTOMERS CAN LEASE LIGHTING from Smitheraft

and General Electric Credit Corporation

Smitheraft LEASE-LIGHT\* is a new nation-wide plan by which owners or tenants can lease Smithcraft fluorescent lighting equipment for old or new buildings.

- Owners or tenants free their capital to earn dividends while enjoying the efficiencies of Lease-Light\*.
- They rent or time-pay for the entire lighting equipment, including installation cost, anywhere in the United States or Canada.
- They lease for 5 years...deposit approximately 5 months rent...10 months if installation cost included.
- Your customers Lease-Light\* from Smithcraft through you and your Distributor. Their payments are sent to General Electric Credit Corp.
- Lease-Light\* rentals for recommended lighting levels for stores, offices, factories and schools run as low as %¢ per square foot per month.
- Your customers choose from Smithcraft's complete line of fluorescent fixtures or light- and soundconditioned ceilings.

You can generate more jobs in the modernization and re-lighting market, at a higher profit to you, with the Smithcraft Lease-Light\* Plan. For further information, call your distributor or write to

CHELSEA, MASS.

Registered Mark Smithcraft Corporation

Smithenaft CORPORATION

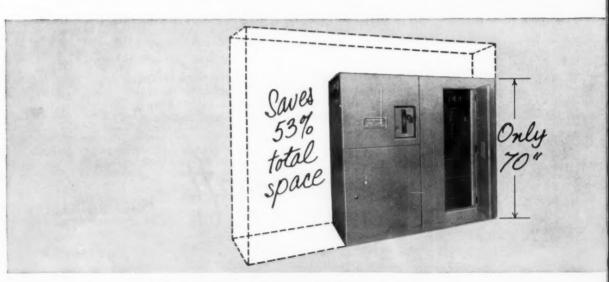
CHICAGO, ILL.

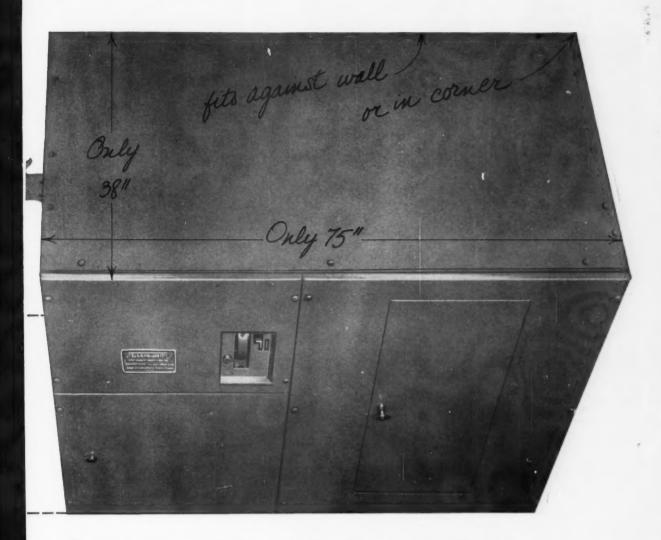
-f- Light-conditioning by Smetheraft - America's finest fluorescent lighting

ELECTRICAL CONSTRUCTION AND MAINTENANCE . . . MAY, 1960



# NEW SPACE-SAVINGEST





# I-T-E TRANFO-UNIT®

Available in capacities up to 500 kva at 5 kv

This packaged unit substation fits in places where others cannot go. In fact, it's actually the world's most compact. 20 in. lower than the old standard, 50 in. shorter. Connects from the front. So you can put it against a wall or in a corner. Dry-type transformer and a wide choice of primary and secondary devices. Send for the complete kit of information. I-T-E Circuit Breaker Company, Dept. TR, 1900 Hamilton St., Philadelphia 30, Pa.



I-T-E CIRCUIT BREAKER COMPANY

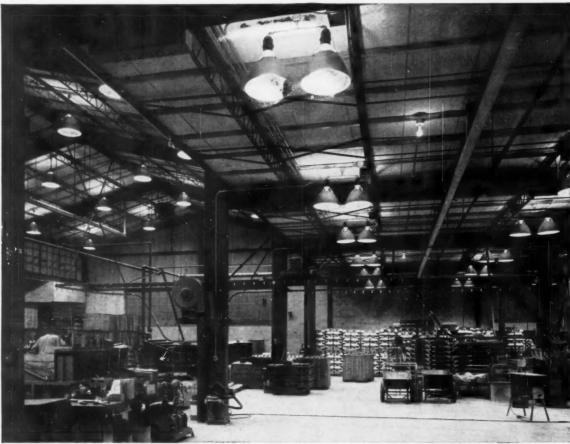


Photo courtesy of Aluminum Casting and Engineering Company, Milwaukee, Wisconsin

#### 225 footcandles!



INSTALLATION DATA

Low bay-Twin-mounted Abolite HMFAU-1800 fixtures with 400 watt color-improved mercury lamps. Mounting height 14', with 13' x 12' spacing. Average footcandle

High bay—Abolite HMFAU-2400 fixtures with 1000 watt color-improved mercury lamps. Mounting height 24½', with 13' x 12' spacing. Average footcandle level: 180. 

Electrical Contractor:

Bentley-Jost Electric Corp.

Abolite lifts the lighting level—This company makes intricate aluminum permanent mold castings. They wanted a higher level of lighting in their foundry to increase worker efficiency. They got it using Abolite fixtures in what some lighting engineers call the most outstanding mercury lighting installation in the country.

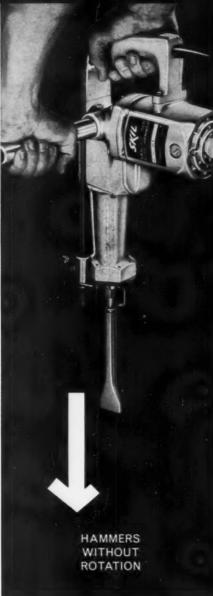
In the low-bay area, there's an average footcandle level of 225, yet there's no glare-both vertical and horizontal surfaces are lighted evenly without any deep shadows. The Abolite fixtures give 35° shielding to lamp, direct 18% of light upward through open top to wash out deep ceiling shadows.

Most important, this system costs less than a comparable fluorescent system because fewer fixtures are needed. Maintenance costs are less, too, because the chimney effect of Abolite's open-top design prevents dirt from collecting on lamp and reflector surfaces. Why not try this system with Abolite fixtures on your next job? For full information, write Abolite Lighting Division, The Jones Metal Products Company, West Lafayette, Ohio.



THE JONES METAL PRODUCTS COMPANY West Lafayette, Ohio







# **New!** Revolutionary Skil Roto-Hammer

Exclusive 3-way action obsoletes all other electric hammers!

It's actually 3 different tools in one:

Powerful hammer with automatic power rotation that drills holes in masonry up to 65 times faster than by hand . . . up to 5 times faster than ordinary hammers . . . without tiresome rotation of star drills.

Hammer without rotary action for all kinds of hammering jobs, including channeling, routing, chiseling, riveting, demolition work, setting self-drilling anchors.

Drill without hammering action for boring holes in masonry, wood, metal, or any material that can be drilled with standard electric drills.

Costs per hole are lowest of any hammer (see chart). Maintenance costs are lowest, too, because of unique "electropneumatic" drive. No springs to break ... powerful hammering is air actuated.

Ask your Skil distributor for demonstration of Model 726 (1/2-1 inch) and Model 736 (1-2 inch). Or write for 8-page brochure. Skil Corporation, 5033 Elston Ave., Chicago 30, Ill. Attention:

Dept. 130-F

#### LOWEST COST PER HOLE

Based on 1000 holes (¾" x 4" deep) in masonry—labor at \$3.00 per hr.

SKIL NO. 726 HAMMER	ORDINARY HAMMER		
1 Carbide Bit* needed	24 Star Drills needed		
19.38 hours of labor	100.4 hours of labor		
\$80.14 (labor & bit)	\$337.20 (labor & bits)		
8¢ per hole	34¢ per hole		

\*New SKIL Carbide Bits stay sharp 20 to 30 times longer than star drills.

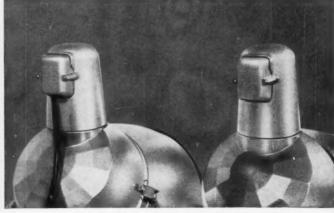


.. and SKILSAW POWER TOOLS



MERCURY Now, 100- to 1000-watt mercury lights give twice the light per watt, 2 to 6 times

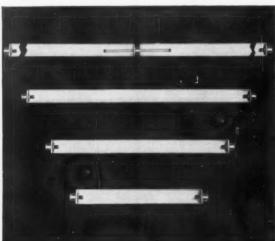


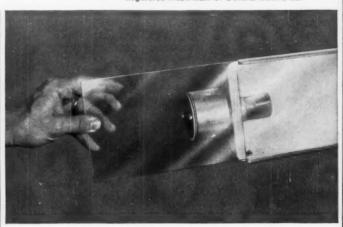


Wired or unwired—get the L-69A prewired, with 4-foot cable, or buy it unwired—to cut cost and splicing time.



FLUORESCENT Fluoroflood\* fixtures are available in 4-, 6-, 8-, or 9-foot lengths—for High
\*Registered Trade-mark of General Electric Co.

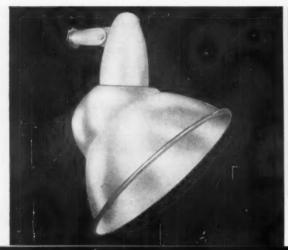


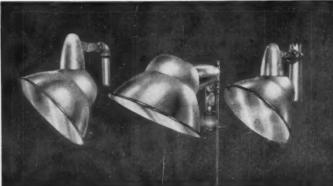


**Cover slips out easily** for simple relamping and maintenance—regardless of position of mounting conduit.



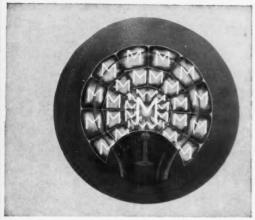
FILAMENT A complete line of filament floodlights—from 250 to 1500 watts, includes a model for





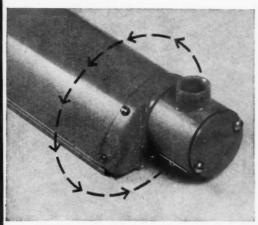
All angle mounting of L-100 and L-55 series (filament or mercury) made possible by threaded mounting stud and locknut.

#### longer lamp life than filament.



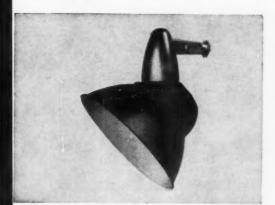
5% to 35% more light—more uniform distribution—with exclusive "diamond back" reflector.

#### Output or Power Groove lamps.

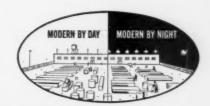


360° rotation of reflector permits mounting at any angle, aiming in any direction.

#### almost any application.



**Economy model**—L-55 open floodlight—features faceted one-piece porcelain reflector.



# Only with General Electric floodlights can you choose from ALL 3 LIGHT SOURCES

More light per unit, better distributed light—For example the optical design of General Electric's Fluoroflood fixture is specifically designed to deliver maximum light in a uniform pattern, eliminating "hot spots" and dim areas. For filament or mercury lighting, G.E.'s exclusive "diamond back" reflector—featured on our L-69A, L-55, and L-100 units, delivers from 5% to 35% more light—light that is usually lost behind the lamp with ordinary fixtures.

and get these important benefits

Fast installation, practically no maintenance—Sturdily designed G-E floodlights are fast and simple to mount, aim, connect, and maintain. The external terminal box on the L-69A (mercury or filament) makes wiring faster and simpler, insulation life is increased many times. The Fluoroflood fixture offers easy access to wiring and complete flexibility in mounting and aiming. Since the reflector can be rotated 360°, you can mount it at any angle, aim it in any direction. Installation and maintenance are greatly simplified since the unit consists of only two end castings with lampholders and a reflector.

Availability from many distributors' stocks—Coast to coast, more than 500 electrical distributors are franchised to supply General Electric floodlights from stock or by prompt shipment. Remember, General Electric premium quality floodlights cost no more than ordinary floodlights.

Call in your G-E Distributor today for the complete story—or send in the coupon below.

# GENERAL DE ELECTRIC

Section C450-14, General Electric Co	mpany	, Schenectady, N. Y.
Please send me free information o	n the s	ubjects checked below:
☐ Filament Floodlighting		Fluoroflood Fluorescent Fixture
☐ Mercury Floodlighting		Floodlighting Application Manual
Name		
Company		
Street		
City S	tate	



If power fails...
lights go on!

Yes, when the power goes off, Exide Lightguard\* goes on automatically—prevents panic, injury and damage. Exide Lightguard plugs into any regular outlet—has a built-in automatic charger. Batteries last for years. You have a choice of several models. For full details, write Exide Industrial Division, The Electric Storage Battery Company, Phila. 20, Pa.







#### No bolts, no screws, no drilling

with new Permacel Junction Box Mount epoxy adhesive . . . the fast, easy way to attach junction boxes to any surface.

# PERMACEL

NEW BRUNSWICK, NEW JERSEY . TAPES . ELECTRICAL INSULATING MATERIALS . ADHESIVES



BEFORE "Operation UPlight" Assembly Products, Inc., of Chesterland, Ohio, had to supplement their general lighting system with additional fixtures to provide sufficient illumination at work levels for their precision manufacturing operations. This combination resulted in extreme brightness variations.

# Only 10° per hour\*...



"The combination of at least 300 footcandles along with the determination of the most practical mounting height (7'6") made the selection of the lighting fixture at Assembly Products, Inc. an extremely critical consideration,"

says Consulting Engineer Anton J. Eichmuller Cleveland, Ohio

"However, after seeing the results of the installation, we were firmly convinced that our choice of Day-Brite CFI-30 Power-Groove Industrials was right. The resulting low-brightness and high efficiency are evident to all; most importantly to the people working in the area because it eliminates eye fatigue.

"Of almost equal importance are the excellent design and construction features of CFI-30, which were attested to by the electrical contractor (Herbst Electric Co.) who installed the Day-Brite units. These features too will pay big dividends to the owner for years to come.

"The excellence of the results, plus the fine handling of the order by Day-Brite factory and local representatives, have given us another outstanding job, fully appreciated by Mr. Saint Amour (President, Assembly Products) and myself. This is an example of another Day-Brite installation well received and appreciated."

A. J. Eichmuller (right) and Day-Brite representative Tony Dunn examine the Day-Brite CFI-30.



AFTER "Operation UPlight" Day-Brite CFI-30 fixtures, equipped with Power-Groove lamps, boosted illumination to 300 footcandles and balanced brightness with  $22\frac{1}{2}\%$  uplighting. Fixtures were mounted in continuous rows on 7-foot centers,  $7\frac{1}{2}$  feet above the floor. The ACTUAL difference is even greater than these photographs show.

# for 300 footcandles

## More light for less money with Day-Brite CFI® fixtures!

That's "Operation UPlight". The new Day-Brite CFI (Comfort For Industry) fixtures are designed to deliver the higher lighting intensities currently recommended... yet substantially reduce installed, operating and total owning costs. And now, with prices reduced as much as 17.7%, Day-Brite CFI fixtures are within the range of every industrial lighting application.

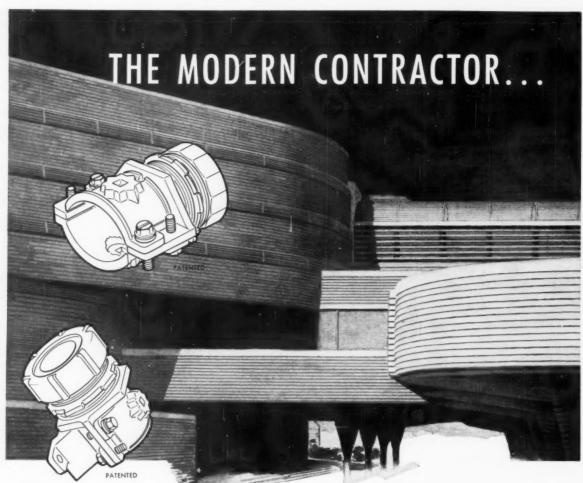
For actual cost figures comparing Day-Brite CFI fixtures with other lighting systems, call your Day-Brite representative listed in the Yellow Pages. See for yourself why hundreds of companies across the country have put "Operation UPlight" into action, making it the most successful program in Day-Brite history. PHONE TODAY!

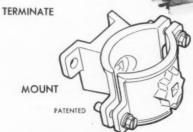
\*\*Exper footcandle for each 10,000 square feet. Based on 4,000-hour operation, 1¢ per KWH rate, 35% lamp discount, typical maintenance cost, and amortizing the cost of buying and installing the lighting units over a ten year period.



Day-Brite Lighting, Inc. St. Louis, Mo. • Santa Clara, Calif.

NATION'S LARGEST MANUFACTURER OF COMMERCIAL AND INDUSTRIAL LIGHTING EQUIPMENT

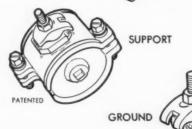






# T&B MODULAR FITTINGS SYSTEM FOR INTERLOCKED ARMORED CABLE

...to Fully Take Advantage of its Flexibility



ELIZABETH.

With the Modular Fittings System you specify the fitting to suit the installation. Terminate, Dead End, Support, Ground, Mount, Pot Head, Wet or Dry, T&B Modular Fittings can solve all these problems, at Lowest Installed Cost.

Write for our Free Eye-Opener Series and learn how you may profit from this new System.



SOLD COAST TO COAST EXCLUSIVELY BY YOUR LOCAL T&B DISTRIBUTOR

#### THE THOMAS & BETTS CO.

INCORPORATED

IN CANADA, THOMAS & BETTS LTD. MONTREAL



"You can count on Niagara. Really cooperative. They've never let us down."

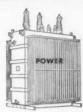
Sensitive to the needs of its customers, Niagara has proved its flexibility time and time again in scheduling urgent deliveries. Doing the "impossible" is not uncommon in this organization. Close, personal, *triendly* attention is uppermost. Even shipments are planned to minimize unloading costs.

Built in accordance with established standards or to specified requirements, Niagara Transformers cover practically every service through 10,000 kva, 69,000 volts. Write for Bulletin 139. Niagara Transformer Corp., P.O. Box 23, Buffalo 25, N. Y. Representatives in principal cities.













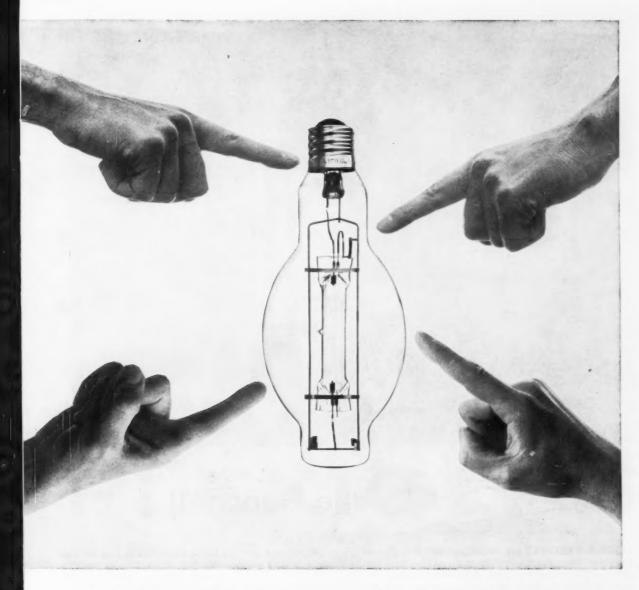




## Mercury lamps may look alike

These Mercury lamps look alike and cost about the same, but one—the Westinghouse Lamp—will deliver more light initially and maintain this high light output longer. It is your most economical choice for industrial and commercial lighting and incorporates all 4 outstanding improvements listed below.

1. Lifeguard  $^{\mathsf{TM}}$  arc tube to improve lumen maintenance. Even after 10,000 hours of use, these lamps will still give 85% of their initial light output. This means that  $2\frac{1}{2}$  years after you install Westinghouse Mercury Lamps, your plant or streets will have almost the same high level of light as when the lamps were new!



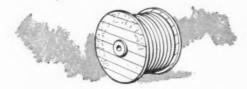
## ... but four differences make one a better buy!

- 2. New design electrodes lock in the emission material and insure long life and easier starting.
- 3. Weather Duty™ construction. Special glass is resistant to thermal shock and corrosive fumes. Moisture, industrial fumes, even snow and rain can't harm these Westinghouse Mercury Lamps.
- **4. Hi-temp silicone cement** holds bases tight for life . . . actually gets stronger as the lamps burn. No drop-outs. Westinghouse even date-codes its mercury lamps so you can check performance.

No matter what type or wattage of mercury lamps you use, you will get more value and light for your money—plus longer, trouble-free service—by specifying and insisting on Westinghouse Mercury Lamps. Westinghouse makes the most complete line of mercury lamps in the industry . . . 100 to 3000 watt sizes . . . in clear, color-corrected and reflector types. Contact your authorized Westinghouse lamp agent or nearest Westinghouse sales office.

YOU CAN BE SURE ... IF IT'S Westinghouse Electric Corporation, Bloomfield, N. J.

### TO CORNER more new electrical



kind and size

contracts...of the



you want, you

need advance news on jobs



coming up-so you

can concentrate



that are best for you. You need



Dodge Reports!!

DODGE REPORTS are individual building project reports. They're mailed to you daily. You get REPORTS on just the types of building you're interested in. They tell who's going to build what and where ... whom to see ... when bids are wanted ... who else is biddi-g...who gets which awards.

When you use DODGE REPORTS, you always know what's coming up. You don't depend only on invitations to bid. You concentrate on jobs you know will be profitable.

If you do business in the new construction field, you need DODGE REPORTS.

#### SEND FOR THIS FREE BOOK

F. W. Dodge Corporation, Construction News Division 119 West 40th Street, New York 18, N. Y., Dept. ECM50 Send me the book: "How Subcontractors Get More Work in New Construction" and let me see some typical Dodge Reports. I am interested in the general markets checked below.

- General Building ☐ House Construction
- ☐ Engineering Projects (Heavy Construction)

Area

Address



GET MORE BUSINESS



# PLEXIGLAS

...for lighting that stands out and stands up



Handsome buildings deserve the best in lighting, and they get it when lighting equipment includes diffusers or lenses made of Plexiglas® acrylic plastic. Plexiglas provides highest efficiency in transmission and diffusion. It is rigid, with a smooth, easily cleaned surface. Above all, it is a durable material—highly resistant to breakage, and free from discoloration even after years of exposure to fluorescent light.

We will be pleased to send you the names of manufacturers whose lighting equipment is based on the use of Plexiglas.



Chemicals for Industry

## ROHM & HAAS

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

In Canada: Rohm & Haas Company of Canada, Ltd., West Hill, Ontario

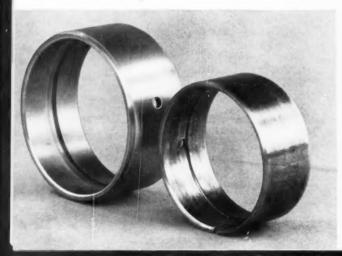
# An amazing metal up to 3 times



"Silver circles" as hard as Swedish steel make your Onan Plant last longer.

**Big, brawny bearings**—twice the size of many competitors' bearings—give Onan Plants a longer life between overhauls. Onan is built *up* to performance, not down to a price.

To give you greater assurance of top performance, inspectors from an independent laboratory periodically visit our factories to test units and production testing methods.





# the valve life!

Onan exhaust valves and seats are coated with Stellite, a tough alloy, to greatly reduce wear and burning

Stellite—one of the toughest alloys known—gives the exhaust valves and seats in an Onan engine up to 300% longer life. Scorching punishment—Stellite can take it.

Onan's attention to important details, like valves and valve seats, is what makes Onan Plants so dependable, so long-lasting, so economical.

And, only Onan gives you Performance Certified. Every Onan Electric Plant is run for hours under full load before it leaves our factory to assure ourselves, and you, of getting all the performance and power you paid for. To give you even more assurance, inspectors from an independent laboratory come in periodically to double check our tests and testing methods. Whether you need primary or stand-by generating power, from 500 watts to 230,000 watts, see your Onan distributor. You'll find his name in the telephone classified section in every major city, or write direct.

### ONLY ONAN GIVES YOU THIS GUARANTEE



D. W. ONAN & SONS INC., 2574 UNIVERSITY AVE. S.E., MINNEAPOLIS 14, MINN.

## NOW!

-

# Support



# Time to call your electrical contractor

TV picture "jiggles" may mean you've got a case of "low housepower." The safest, surest way to find out is to call a qualified electrical contractor. He has the up-to-date knowledge, trained personnel and specialized equipment to diagnose your electrical ailments and to prescribe the best remedy. And you can depend on him to use only the best quality materials—like "Scotch" Brand No. 33 Electrical Tape... because he knows that any electrical circuit is only as safe as the insulations that contain it.

SCOTCH No.33

... preferred by most electricians ... everywhere!

OVE

23,000,000

readers are exposed to each of these "SCOTCH" No. 33 ads in THE SATURDAY EVENING POST!

### Sparking sales for you

Now...3M — makers of SCOTCH No. 33 Electrical Tape — sponsors a new promotion to support you...the electrical contractor!

STRONG ADS LIKE THIS which build business, confidence and public goodwill for you...are now appearing in THE SATURDAY EVENING POST!

Now 3M not only gives you "Scotch" Brand No. 33—the top all-around plastic electrical tape—they also give you business building advertising support! These ads, on a regularly scheduled basis, are appearing now in the leading opinion-making magazine—The Saturday Evening Post—reaching your best prospects for wiring and rewiring jobs among householders and business and industrial management. Each ad supports you directly as the man to see for the best wiring job for any purpose. Watch for these ads in The Saturday Evening Post!

SCOTCH NO. 33

... preferred by most electricians... everywhere

**Electrical Products Division** 

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW





# y SOLID BRASS WEATHERPROOF

Bell's field and laboratory tests have proved that only rugged, Solid Brass weatherproof plates can stand up, year in —year out, regardless of weather and heavy use.

Want more proof . . . just look at this list of exclusive Solid Brass advantages

Bell Solid Brass

will withstand sudden shock and impact, will not crack or shatter

> Bell Solid Brass will not flake, peel, pit or corrode

Bell Solid Brass

is impervious to salt air, smoke, industrial gases, fumes and steam

Bell Solid Brass

is unaffected by lime or acids found in brick, mortar, lime and cinder block

Bell Solid Brass wears better, lasts much longer in any climate . , , even in coastal areas



Saf-T-Lok COVER

snaps open

stays open

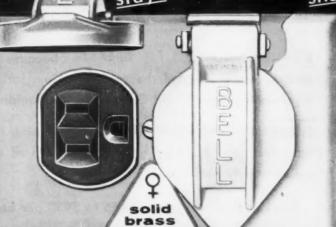
snaps shut

.040 SOLID BRASS

BELL

...better to buy

...easier



ALUMINUM FINISH

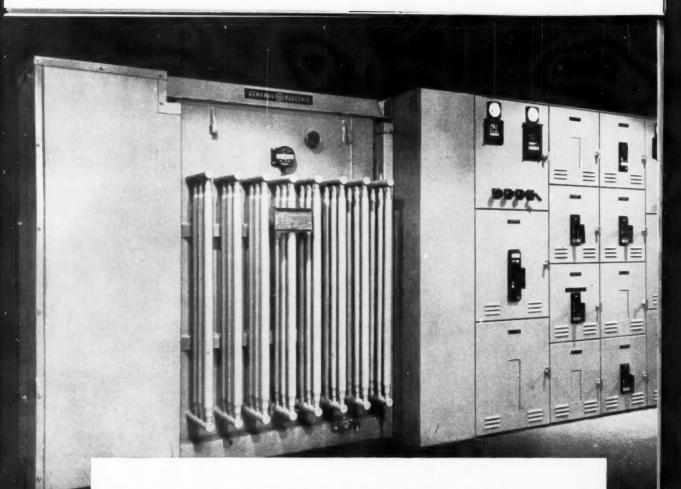
Write for fully illustrated catalog

Look for this Label ?. A sign of Quality

BELL ELECTRIC COMPANY 5735 S. CLAREMONT AVENUE, CHICAGO 36, ILLINOIS

America's Largest Line of Weatherproof Devices and Covers

ELECTRICAL CONSTRUCTION AND MAINTENANCE . . . MAY, 1960



Selectively Coordinated load centers give maximum service continuity . . . and now cost you less

1. SAVE UP TO \$600 PER BREAKER because General Electric has eliminated the price premium for selective trips when supplied with G-E switchgear equipments.

2. SAVE UP TO \$630 PER BREAKER by using manually operated, stored-energy breakers in place of electrical units formerly required.

Total savings vary from \$465 to \$930 per breaker, depending on size.

How much can you save? Ask your General Electric sales engineer.



General Electric Selectively Coordinated

Load Center Unit Substations now are . . .

# Yours at Lower Cost

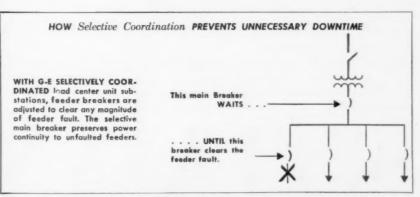
YOU NOW PAY LESS You can purchase G-E Selectively Coordinated load center unit substations at new low prices. General Electric has eliminated the price premium normally charged for this inherently higher-cost, more highly-engineered product. This means that you can now get superior service for the same price as the more common, but less "intelligent," fully-rated load center unit substation. Further savings can be realized by the use of manually operated stored-energy breakers.

SELECTIVELY COORDINATED LOAD CENTERS MINIMIZE DOWNTIME In the Selectively Coordinated load center, the tripping times of the main and feeder breakers are coordinated so that during short-circuit conditions, power is removed only from the faulted feeder. Power continues to flow to the unfaulted feeders—thus preventing costly, unnecessary downtime. (See diagram below.)

SIMPLY SPECIFY SELECTIVE COORDINATION

Order the *Selectively Coordinated* load center. Upon delivery, you will receive time-coordination curves which show you the factory-preset characteristics of each breaker, how they combine to assure you of the best possible service continuity.

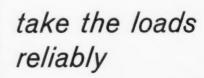
For more detailed information, contact your nearest G-E Apparatus Sales Office or write to General Electric Co., Schenectady 5, N. Y. for bulletin GEA-3592. 531-01

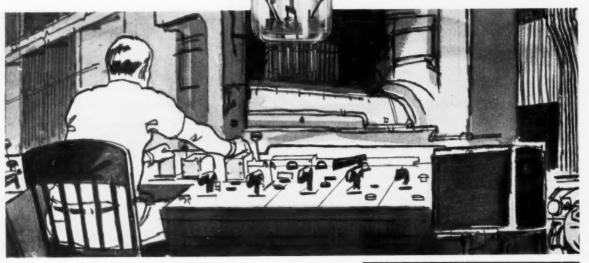


Progress Is Our Most Important Product

GENERAL & ELECTRIC

# **SYLVANIA** INDUSTRIAL **TUBES**





Sylvania Industrial Electronic Tubes prove their ability in daily use to withstand widely varying load conditions. Vibration? Shock? They're built to take that, too, and still perform reliably.

Next time you need superior-quality replacement tubes see your Sylvania Industrial Tube Distributor. Better yet, see him soon and have your replacements on hand. He handles the full line of Sylvania Industrial Tubes for resistance welding, electronic control, induction heating and dielectric heating equipment.

Meet your SYLVANIA INDUSTRIAL TUBE DISTRIBUTOR. Ask him for the new "Sylvania Industrial Tubes" and "Gold Brand Reliable Tubes" booklets. Or write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. 155,1100 Main Street, Buffalo, N. Y.

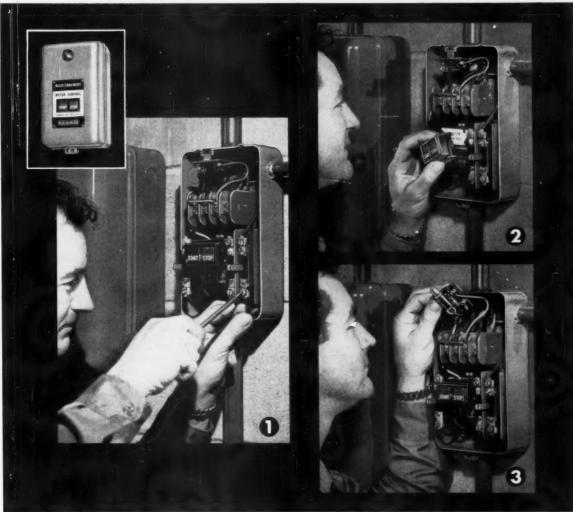
Sylvania	Starting	Operating	Operating C	urrent (ma
Type	Voltage	Voltage	Min.	Max.
VOLTAGE	-REGULATOR	TYPES		
OA2	155	150	5	30
OB2	115	105	5	40
OB3	125	90	5	30
003	135	105	5	40
OD3	180	150	5	40
5644	130	95	5	25
VOLTAGE	-REFERENCE	TYPES		
5651	115	87	1.5	3.5

Subsidiary of GENERAL TELEPHONE & ELECTRONICS



## **ALLIS-CHALMERS**





# Flexible design for easy modification

### featured in this new complete line of low voltage motor control

The modern, flexible design of this new line of Size 0 through 4 Allis-Chalmers control permits making many modifications in the field with ease. Minimum parts requirements facilitate delivery from local stock.

- A third overload relay can be added to any Allis-Chalmers enclosure in the field, by use of just two screws.
- 2. Start-stop buttons and selector switch kits are "plug-in" mounted.
- Only one pilot light kit is needed for any size starter, any standard voltage.
- Auxiliary contacts fit any size starter, 0 through 4.

Accessibility — Wide-open design permits fast installation, modification, inspection and maintenance.

Unsurpassed Mechanical and Electrical Life — Millions of "life test" operations attest to the functional quality in every detail — assure the

ultimate in dependable performance and sure protection for personnel, motors and machines.

A complete line of low voltage control (Size 0 through 9) and high voltage control in all NEMA enclosures, plus engineered control systems. Your A-C distributor or representative will give you all the details. Or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

A-1282

# The case for 277 volt lighting and ASCA Remote Control Switches

AT THE NEW ASCO PLANT ...

Remote Control Switches for feeders and branch circuits greatly simplify load control. Fast and reliable on-off control over large blocks of 277 volt lighting can be exercised from any control point.

ASCO Bulletin 920 Mechanically Held Remote Control Switches (shown mounted on a column) control large blocks of lighting in the manufacturing area. Control is by pushbutton from a convenient point.

Bus top switch
fixed at 20A

30-A, 3-P
Remote control
awicht
(Mechanicallyhald conform)

Control
Cricuit

PT

Gental burlen

30, 4x circuit
to lighting ladd
station

BASIC HOOKUP OF
REMOTE CONTROLLED
LIGHTING CIRCUIT

UL

The Bulletin 920 Remote Control Switch is U. L. approved to 600 Volts A-C, and is catalog listed in sizes from 30 to 200 amperes, 2 and 3 pole.

Use of the 277/480 volt Wye system and development of the 277 volt discharge lamps were made possible by the 1953 Code. Section 2113 extended the higher voltage branch circuits as follows:

"Section 2113, Voltage. (2) in Industrial establishments, office buildings, large schools and stores, the voltage of branch circuits which supply only the ballasts for electric discharge lamps in permanently installed fixtures mounted not less than eight feet from the floor, which do not have manual switch control as an integral part of the fixture, may exceed 150 volts to ground, but shall not exceed 300 volts to ground."

The expanded use of 277 volt lighting in office buildings, factories, stores, schools, and technical centers results from the many advantages of this system:

- Reduction in number of circuits—since loads can be combined
- 2. Reduction in wire sizes
- Increase in the number of fixtures per branch circuit (2.3 times 120 volt systems)
- 4. Use of same system for both power and lighting

Substantial blocks of 277 volt lighting can be controlled remotely through the use of ASCO Remote Control Switches, providing these advantages:

Installation Economy - Distribution panels can be located to provide straight feeders and short branch circuits, resulting in minimum line drop and losses.

Control Convenience - Control stations located conveniently - connections made using small wires provide instant disconnect of lighting and power feeders.

Design Simplicity and Flexibility-Logical distribution determines design-makes wiring layout simple and flexible for future expansion.

Safety in Emergencies - Instant control of vital circuits from one or more accessible locations.

And ASCO Remotes can be used up to their full rating on 277 volt fluorescent loads.

### DEPENDABLE CONTROL BY ASCO

ASCO Mechanically Held Electrically Operated Remote Control Switches are ideal for 277 volt lighting applications. ASCO Remotes are unaffected by line voltage conditions, and respond only to the control of the pushbutton, time switch, relay or other controlling device. These switches are available from 30 to 1000 amperes—to 750 volts A-C or D-C—for all classes of load.

For complete engineering information on Remote Control Switches, write for new Catalog 57-52.

## ASCO Electromagnetic Control

Automatic Switch Co. 50-K HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600 AUTOMATIC TRANSFER SWITCHES . SOLENOID VALVES . ELECTROMAGNETIC CONTROL



NEW RACO LINE OF FITTINGS



Charlie Raco has a new hat!

RACO, the complete box line, now offers you a complete line of fittings, too. There's a full line of RACO fittings for rigid conduit, E.M.T. (thinwall), armored cable, flexible metallic tubing, non-metallic cable, and service entrance cable.

And...the new RACO fittings are available in malleable iron, aluminum, steel, and pressure cast.

With this new addition to the RACO line, you now have a top-quality source for all your roughing-in materials. Your RACO Distributor has the new complete line of RACO products. Ask him about their time and money-saving features.





Rigid Conduit



EMT (thinwall)



**Armored Cable** 



Metallic Tubing



on-metallic Cable



Service Entrance

NOW RACO HAS A COMPLETE LINE OF ROUGHING-IN MATERIALS



ALL-STEEL EQUIPMENT INC. Aurora, Illinois

# 5 DONUSES when you specify and/or install

### DONUS NO. 1 . . . EXTREME QUIETNESS

Quiet transformer operation with low loss is a blessing and a real source of satisfaction to building owners, managers, top executives, employees and patrons.

Therefore a superior low noise level is an extremely important reason why you should specify and/or install PTC transformers on all jobs.

Look at these PTC low noise levels as they compare with present and recommended NEMA specifications.

KVA Transformer Rating	Present NEMA	Precision Aver Standard Design	rage Sound Level Special Design
9-30	50	40	34
371/2-1121/2	55	42	38
125 - 167	60	44	42
200 - 300	62	48	46

To recognize the extreme quietness of PTC transformers it is best to compare them in decibel sound level ratings with those of typical sounds familiar to everyday life.

#### FOR EXAMPLE:

- 60-70 decibels-the sound of one typewriter or average traffic sounds 100 ft. away.
- 50-60 decibels—the sound of a vacuum cleaner or moderate restaurant clatter.
- 40-50 decibels the noise to be found in an average residence or in normal conver-

30-40 decibels-low conversation in a residence in the evening

### DONUS NO. 2 . . . EFFICIENCY

Transformer losses cost money. Precision transformer cores 1 use the lowest loss steel available. Precision transformers are wound with low resistance copper wire and designed for the greatest possible operation economy. These features reduce losses and save dollars not once, but year after year.

### DONUS NO. 3 ... OVERLOAD CAPACITY

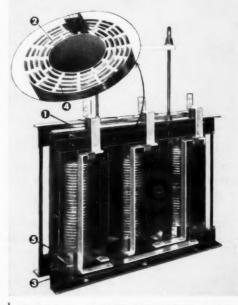
Precision transformers are designed with large open ducts 2 for efficient cooling and operate at lower temperatures than specified in national standards. Superior PTC insulation materials, varnishes and wire enamels actually permit operating temperatures in excess of these standards with no loss of life. factors together with low losses give Precision transformers unequalled ability to handle overloads.

### DONUS NO. 4 . . . DEPENDABILITY AND LONG LIFE

Dependability and long life can result only from ADVANCED DESIGN and BUILT-IN QUALITY. PTC transformers excel because they are constructed to meet the varying conditions under which they must be used. Additional PTC features are:

- Core laminations are clamped together with structural steel (3) rather than formed sheet steel for more rugged construction.
- Glass laminate duct spacers 4 used provide greater toughness, rigidity, dimensional stability, and moisture resistance far in excess of wood or paper phenolic laminate spacers
- Coils are thoroughly clamped and braced around the core with fibre-glass laminate insulating blocks 6 resulting in greatest structural and tensile
- Coils are made with an interlayer and interwinding insulation of Mylar-Quinterra and glass, assuring high dielectric strength, low moisture absorbtion and high temperature stability characteristics.





### DONUS NO. 5... REDUCED INSTALLATION EXPENSE

Well designed and easily accessible mounting provisions together with ample connecting space and simple wiring termination mean neater installations at lower than normal cost.

### DONUS NO. 6 . . . THE ONLY 5-YEAR UNCONDITIONAL GUARANTEE IN THE INDUSTRY

Your reputation as an electrical engineer or contractor depends upon YOUR ability to stand firmly behind your recommendations and installations.

It is reassuring to know that PTC transformers work because PTC people make them work — then stand unconditionally behind them.

#### WHISPER-QUIET INSIDE-THE-WALL INSTALLATION

Precision Transformer Corporation has developed a unit which installs inside-the-wall in otherwise unusable space. Precision's "HUSH-FLUSH" design permits easy, full accessibility, lowest noise level close to lead power service. Saves material and labor costs. Ideal for schools, libraries, hospitals, churches, theatres, etc. - wherever noise must be eliminated.

#### Complete Line - DRY and LIQUID Types

Whatever your transformer needs, there is a dependable, quiet, long-lasting dry or liquid type transformer ... more than 4,000 models ranging from ¼ to 5,000 KVA.

Write today for 4-page brochure providing details on the PTC line.

- QUIET EFFICIENT
- DEPENDABLE

### PRECISION TRANSFORMER CORP.

West Lake Street

Chicago 12, Illinois

Representatives in all principal cities

# Stronger, Lifetime Flashlight Power





at a Fraction of "D" Cell Cost.

## Heavy-Duty Sonotone Rechargeable Flashlight Battery Cartridge



To recharge, just unscrew cap...



and plug overnight into any 110-120-volt AC outlet.

- A multi-use adaptation of the patented Sonotone sintered-plate, nickel-cadmium battery used in space missiles and jets.
- Gives at least 3 hours of strong, continuous light from a single charge with PR-6 bulb—or1½ hours with full-powered PR-2 bulb.
- Dependable in extreme temperature and weather conditions.
- Can be recharged hundreds of times at about ¼¢ per charge.
- Sturdy, leakproof construction aluminum jacket — electrically shockproof.
- Full-year guarantee under heavy industrial use backed by Sonotone's leadership of over 30 years in precision engineering and service.



A completely new concept in flashlight battery efficiency and economy for industrial users! Replaces and outmodes any two "D" cells, for any purpose, in end-to-end use. Rechargeable overnight by plugging into any 110-120volt AC outlet. Gives maintenance and service personnel a battery with a lifetime of use at a fraction of the cost of constantly replaced "D" cells. Dozens of applications - with railroads, aviation lines, municipal departments, public utilities and private industries. Heavy-Duty Model FC-3 (\$9.95 retail) - subject to your usual discounts. Also Standard Model FC-2 for home use (light lasts at least 11/2 hours with PR-6 bulb) -\$7.95 retail. Write now for full details to:

Sonotone Sattery Division, Dept. B56-50

ELMSFORD, N.Y.

Leading makers of fine transistor hearing aids, ceramic phonograph cartridges, speakers, microphones, electronic tubes, sintered-plate, nickel-cadmium batteries.

For dependable protection of electrical wiring . . .

### **USE RIGID STEEL CONDUIT**

When you install rigid conduit made of steel, you obtain *permanent* protection against the ever-present hazards of faulty electrical circuits.

The proof is in the performance of thousands of steel conduit installations over the past 50 years. And the reasons are simple:

### Strength and toughness

Steel prevents physical damage to the wires, protecting them permanently.

### Good electrical conductivity

Steel carries off dangerous fault currents to remove the threat of fire and shock.

### Heat resistance

Steel conduit prevents possible fire from spreading to the building.

Rigid steel conduit is inexpensive to buy, easy to install, simple to rewire. It's compatible with all construction materials in major use, and will often outlast the building itself. Ask your nearest electrical distributor for full details.

BETHLEHEM STEEL COMPANY BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL



# FREE-\$50 IN REMCON DEVICES!

Builders, architects, homeowners—to-day everyone is looking for the little touches of luxury that make a home more desirable, more saleable. Low-voltage switching is just the "extra" that can help you provide your customers with comfort and convenience through electricity. And now with REMCON, the low-voltage system that's practical in any home regardless of cost, you can do it at a profit!

### WHAT IS LOW-VOLTAGE SWITCHING?

Low-voltage switching is the greatest advance in light control since the pull chain. By eliminating the need for elaborate, costly wiring, it provides the ultimate in versatility and safety through multi-point, master-control and path-of-light switching. Low voltage switching also ends shock hazard by putting only 6 volts at the switch.

### 4 REASONS WHY REMCON IS EASIER TO INSTALL

REMCON builds the transformer right into the relay to make low-voltage switching easier four ways: 1. No separate low-voltage source (eliminates additional wiring); 2. No complicated systems. With REMCON, installation is as simple as connecting the three wires of the relay to the three color-coded wires of the switch: 3. No more need to run heavy armored cable from fixture to switch; in fact ... 4. No more switch box! Any way you look at it, there's no longer any reason to shy away from modern low-voltage wiring-especially when you think of the time, labor and money it saves!

### THOUSANDS OF DELIGHTED USERS

Contractors everywhere are delighted with REMCON's flexibility, whether they wire tract or custom homes. Read these:



"Remcon helps me provide luxury at a profit even in a \$15,000 home. I can build in three- and four-way switching quickly-at lower labor costs-because Remcon's #18 wire staples to studs. I'm sold, and my tracts go just as fast." Sidney Gotowner, Gotowner Electric, Gotowner Electric,



"Even in a custom home, small details like Remcon's pilot-light switches and hi-fashion switch plates are appreciated. Remcon plates, for example, blend with and enhance any room's decor. They're practical in any home." Ephraim Berkovitz, Turnpike Electric.



### REMCON—THE ANSWER TO CUTTHROAT COMPETITION

The need for contractors to "trade up" their customers is so important today that the National Electrical Contractors' Association made it the prime topic of discussion at their recent convention. How do you break out of the vicious circle of low bids, cheap services, poor or no profits? By offering the "plus" that pulls you away from the pack...REMCON!

### NOW ACTUALLY COSTS LESS!

Before this \$50 Bonus Program, the ease of installing REMCON was more than enough to offset the slight expense over outmoded, conventional wiring. But even that's been changed. Now REMCON gives you a Certificate worth \$50 in the REMCON devices of your choice—just for trying REMCON on your next job.

### REMCON SUPPORTS YOUR SELLING EFFORTS

To make it still easier for you to sell, REMCON is now in the midst of an extensive advertising and promotion campaign which includes full-page colorful ads, direct mailings to builders and architects, and an intensive publicity effort that has paid dividends in a steady barrage of articles in leading newspapers and magazines.



### **HOW THE \$50 BONUS PROGRAM WORKS**

Go to your distributor. Buy your first package of REMCON materials (it's enough to wire the average three-bedroom house). This package will also contain:

1. A Materials Certificate worth \$50 (list) in the REMCON materials of your choice; 2. A request form for obtaining free business cards imprinted with your name; 3. Free envelope stuffers for you to distribute to your customers; 4. Free truck decals; 5. Complete REMCON literature, including an Electrician's Manual, an illustrated instruction manual, easy-to-follow installation data sheets and wiring diagrams, and articles describing typical industrial and residential REMCON installations. You also get all new information as soon as it's issued. In addition, you will automatically be listed as an Authorized REMCON Dealer, which entitles you to our free Consultation Service—you send us your prints and we'll send back a REMCON switch layout and a list of the materials needed to do the job. The \$50 Bonus Program is now in effect. Go to your distributor today!



stand I am unde	MCON Distributor. I under
NameAddress	MAIL



# **1960**–16,450,000 horsepower **1965**–26,000,000 horsepower

Conservative estimates place the total horsepower of all motors driving fans and blowers in the United States at about 16,450,000 horsepower. And in 1965 it is estimated that the total will be about 26,000,000 . . . an annual growth of 5% for the air moving industry. To make sure all this equipment gives top performance requires careful matching of motor to equipment . . . and a wide variety of different types of motors. Century Electric application engineers can help you select the right motor for your fans, blowers and allied equipment:

For fans—Two basic types of motors, CS and CP, meet most requirements for fans operating from single phase power. Both these Century Electric capacitor start motors provide high starting torque. Fans operating from polyphase power perform best with SC and SCM motors.

For blowers—If the starting load is light or if there will be short time increases in load, then the Century Electric Type SC polyphase motor is ideal. It will give you enough starting torque, and with low starting current. It comes in ½ to 400 hp sizes. If you need two, three or four different fixed speeds while the blower is running, the Century SCM polyphase motor will do the job.

For compressors—Where high starting torque is required to overcome great inertia or backpressure, the Century Electric Type SCH polyphase motor is right. This motor comes in sizes ranging from three to 400 hp and in dripproof,

totally-enclosed and explosion-proof enclosures. It also provides the right kind of power to drive reciprocating pumps with high starting torque requirements.

For pumps—Centrifugal pumps, whose torque demands increase with speed, perform best with Century Electric SC polyphase motors. Reciprocating pumps with high starting torque requirements need the SCH. For all types of pumps, as well as for compressors and blowers, Century Electric makes single phase motors.

For special applications—Century Electric makes a variety of motors for specific operating conditions. The shaft-mounted fan motor is designed for unit heaters and evaporators. It comes in  $\frac{1}{2}$ 3 to 3 hp sizes. Hermetic motors can be built right into a refrigeration compressor unit . . . they are manufactured under rigid quality controls to make sure they are free of contaminants that could damage capillary tubes and valves.

FOR MORE INFORMATION
—Please contact your nearest
Century Electric Sales Office or
Authorized Distributor, You
will find Century Electric's
new Motor Application Guide
helpful...please write for
bulletin 270A. For more than a
motor...

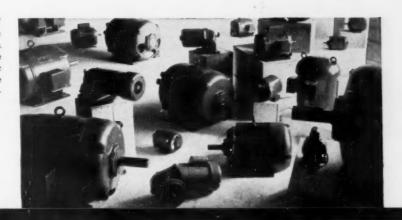


### CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri Offices and Stock Points in Principal Cities

Century 59-8A

FROM OVER 10,000 TYPES of motors—AC and DC . . . single phase and polyphase . . . from 1/20 to 400 hp—you can find the right one from Century Electric for your application . . . the one that provides the best performance commensurate with cost.





# NEW POTTED INDUSTRIAL TRANSFORMER STOPS MOISTURE DEAD!

LONGER USEFUL LIFE WITH 100% COIL AND CORE SEALING... IMPROVES PERFORMANCE, ELIMINATES MAINTENANCE OF WESTINGHOUSE UNIT



Westinghouse developed a silicafilled resin compound for completely encapsulating the core and coils of this industrial transformer. The unit is absolutely impervious to moisture and water-laden industrial atmospheres.

This compact, lightweight transformer is easy to mount . . . can be mounted in *any* position. Attractive appearance and low noise level permit installation of unit *anywhere* without objection. No transformer hum to distract workers

hum to distract workers.

All Westinghouse "EP" transformers bear the UL label. Available in ½-, ½-, ¾-, 1-, 1½- and 2-kva ratings at 600 volts and below for lighting, small motor loads and the

like. For larger load applications, "EP" single-phase units are rated 3 to 10 kva, 5000 volts and below for *indoor* service...3 to 15-kva transformers, 600 volts and below for indoor-outdoor installations. Also available in 3, 6, 9 and 15 kva, 600 volts and below, three phase for indoor-outdoor applications.

Units also available in ratings for auto and buck-boost applications.

Convenient stocks of the Westinghouse "EP" dry-type transformer are stocked throughout the U.S. Contact your Westinghouse sales engineer for complete data on the "EP" line or write Westinghouse Electric Corporation, P.O. Box 231, Greenville, Pennsylvania. J-70938-R

YOU CAN BE SURE... IF IT'S Westinghouse



### ELECTRICAL CONTRACTORS TELL WHY ...



# COSTS LESS INSTALLED



**EASY MEASURE "INCH-MARKS"** save time ... simply measure, cut, install



FULL LENGTH "GUIDE-LINE"® prevents "wows"... wasted material, wasted time



SILVERSLICK® makes wire-pulling up to 37% easier . . . wire pushing easier, too



UNIFORM DUCTILITY assures smooth, accurate bends . . . no costly kinks



UNIFORM CONCENTRICITY . . . fittings fit every time . . . with concrete-tight joints



TURN THE FITTING—NOT THE RUN for easy installation . . . your most pratical raceway



### REPUBLIC STEEL

Worlds Widest, Range of Standard, Steels and Steel Products



The STEELMARK of the American Steel Industry identifies products made of steel. Look for it when you buy.

REPUBLIC STEEL CORPORATION STEEL AND TUBES DIVISION Dept. C-9533

212 EAST 131st STREET . CLEVELAND 8, OHIO

I want to know more about the installation advantages of Republic ELECTRUNITE® Electrical Metallic Tubing.

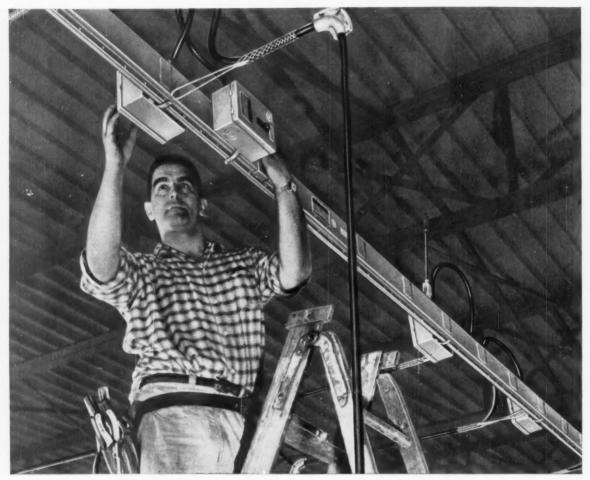
Name Title

Firm\_\_\_\_

Address

City\_\_\_\_\_Zone\_\_State\_\_\_\_\_

# New idea offers more for the money...



## New G-E 100-amp plug-in busway

saves 25% in wiring cost, hailed as "Wiring Method of Tomorrow"

Now, a plug-in busway that costs no more installed—and usually substantially less—than wire and conduit!

Or as a leading electrical contractor in Wilmington, Delaware, puts it: "With Type DH, I can save 25% over the cost of conduit and wire when there are four or more tap-offs in the system."

Type DH—rated 100 amperes, 3 pole or 4 wire, 3 phase 600 volts maximum—serves as either a feeder or plug-in system and may be used wherever exposed wire and conduit might be applied. Light, sturdy and small in size (in cross-section not much larger than a pack of king-sized cigarettes). DH may be hung edgewise on 10-foot centers. Eighteen dead-front outlets are provided in each 10-foot length. For added flexibility, each outlet accepts a variety of fusible, no-fuse and circuit breaker plugs.

G-E distributors, nationwide, stock Type DH, including its wide variety of fittings and accessories. So DH busway matches wire and conduit in availability as well as cost. Ask your General Electric distributor or representative for Bulletin GEA-6172. Or write directly to Distribution Assemblies Department, General Electric Company, Plainville, Connecticut.



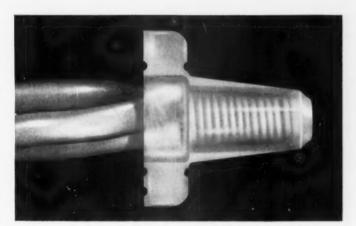
#### DH BUSWAY EXTRA VALUE

Telescoping length adjusts between 42 and 54 inches. This, plus flexible fittings, eliminates need for exact measurements. Rigid fittings—elbows, crosses and tees—adapt busway to virtually any building contour.

GENERAL ELECTRIC

# WING-NUT branch circuit wire connector IS APPROVED

# for ALUMINUM SPLICES



Underwriters' Laboratories has approved "Wing-Nut" for use as aluminum-to-aluminum wire connector for all listed combinations of Nos. 6, 8, 10 & 12 building wire. Since standard aluminum building wire is not now manufactured in No. 14 or No. 16 sizes, combinations including these sizes are not yet approved.

### Easiest Screw-On Connector for Branch Circuit Wiring

U.L. approved for 600 Volts as pressure cable connector, and for recessed fixtures. 474 approved combinations of A.W.G. solid and/or stranded wires.

### **Built-in Wrench**

New wings make it 50% easier to screw on, even on new stiff vinyl-insulated wire. Wings eliminate need for wrenches; can be snipped off after applying.

### Python-Grip

New internal tension-spring coils adapt to shape and size of wires—apply tremendous pressure so great that wires are actually threaded and crushed together.

### **Nylon Shell**

Insulating cap is Nylon...high dielectric, abrasion resistant and high impact strength. You can actually see the splice inside the semi-transparent Nylon shell.



Sold through America's leading distributors. In Canada: Irving Smith, Ltd., Montreal

### WRITE FOR FREE SAMPLES

Send coupon to: IDEAL INDUSTRIES, Inc. 1041-E Park Ave., Sycamore, III.

Name ....

Address.

City

\_\_State\_





# Light weight!

One reason why Alcoa aluminum electrical rigid conduit costs less to install

Heft a 10-foot length of 4-inch aluminum conduit. It weighs just 34 pounds. Compare this with 98 pounds for a similar section of steel conduit.

You benefit from this weight advantage in every phase of handling—lifting, loading, carrying, erecting. Result? Jobs go up faster.

You'll also find that aluminum conduit is easier to cut, bend and thread than conventional conduit. A hacksaw is adequate for cutting most sizes; bending usually is a one-shot task; and regular dies and cutting oils give you clean, sharp threads in a hurry.

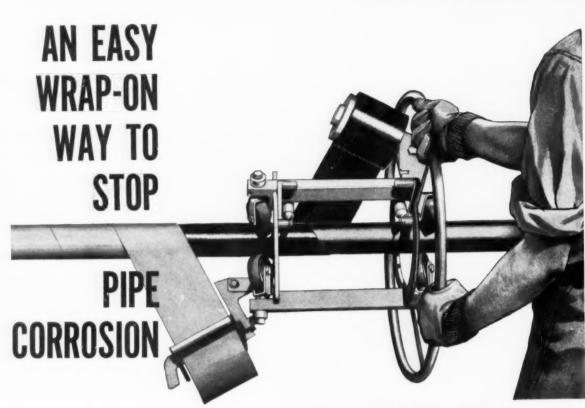
Aluminum conduit is nonsparking, nonmagnetic, corrosion-resistant, and nontoxic. It looks good when you put it up and stays that way for years and years.

Get all the facts and figures in time for your next job. Contact your electrical distributor or one of our representatives. Or drop us a line for free literature. Write to Rome Cable Division of Alcoa, Dept. 7-50, Rome, New York.



OTHER REASONS WHY it costs less to install Alcoa conduityou can cut it easily with a hacksaw, bend with an EMT bender, and thread quickly with a regular sharp die.

ROME CABLE DIVISION OF ALCOA



# Chasekote\*

Pressure-Sensitive Polyethylene Tape has an extra-heavy adhesive mass that clings to clean pipe on contact . . . makes a perfect, permanent bond that rustproofs, waterproofs and insulates pipe against all types

wrinkle-free outerwrap that shields against abrasion, wear, and physical damage to the tape. Wraps simultaneously with the tape. Superior to rag and felt wraps, yet far lower in cost.

\*Trade name of Chase & Sons, Inc., long-famous for protective and insulating

The new CORR-PREV Pipe Coating Team comes in easy to handle tape form. It goes on pipe faster and lasts longer than corrosion-proof paints. It's cleaner and simpler to apply, too, than hot tar coats. And most important, this new CORR-PREV Team offers all the cost-cutting, pipe-saving advantages of polyethylene tape.

With CHASEWRAP Abrasion-Resistant Overwrap and Chasekote polyethylene tape, you get the easiest and best pipe protection at lowest applied cost! There's no heating, drying, clean-up or shut-down time. Each roll is factory-uniform in thickness and quality. And all coating materials - including rental of high-speed applicators - are available from one reliable source. Want samples? Specs? Prices? Write CHASE & SONS, INC., 26 Spruce St., North Quincy, Mass.

tapes for electrical wire and cable















Utility Distribution

FOR YOUR ELECTRICAL INSULATION PROBLEMS SPECIFY CHASE FRICTION, PLASTIC, RUBBER, NEOPRENE AND BUTYL TAPES



### Order these Gedney Connectors with INSULATED THROATS

Liquid-Tite Connectors
Conduit Nipples

90° Short Conduit Elbows

90° Bushed Conduit Elbows

No-Thread 90° Connectors

No-Thread 90° Short Angle Connectors No-Thread 45° Short Angle Connectors

90° Special Conduit Entrance Elbows

No-Thread Connectors for Heavy Wall Conduit

**Watertight Connectors** 

2-Screw Connectors

45° Angle Connectors

90° Angle Connectors

90° Corner Adapters

Bonding Bushings

Service Entrance Cable Fittings

E.M.T. Connectors

90° Short Angle E.M.T. Connectors

90° Long Sweep Angle E.M.T. Elbows

**Offset Connectors** 

Offset Nipples

Added wire protection, faster and easier pull-through...you can now get these added benefits on a complete line of top-quality malleable iron Gedney connectors. Gedney Insulated Throat Connectors eliminate fraying and snagging...leave wire smooth and safe.

Gedney fittings are made from top-grade malleable iron. They're unmatched for toughness and are impervious to corrosion. Each Gedney product must pass rigid inspections.

### **GEDNEY FITTINGS FIT**



# SPECIFY CLIFTON CONDUIT

The conduit with built-in quality

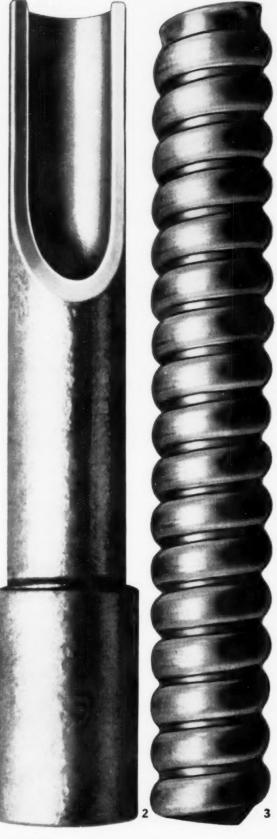
emt (Electrical Metallic Tubing) the only hot-dipped galvanized tubing—inside and out for complete protection oflat, clean, continuous weld for smooth interior surface and ease of pulling during installation.

RIGID CONDUIT made of the finest steel available . Clifton's exclusive process for hot-dipped galvanizing guarantees a uniform zinc protective coating ... inside and out . the finest rigid conduit made. Clifton Rigid Conduit is approved by Underwriter's Laboratories, Inc. and conforms with Federal Specification WW-C581C and ASA Specification C-80.1-1953. Clifton EMT is approved by Underwriter's Laboratories, Inc. and conforms with Federal Specification WW-T-806B and ASA Specification C-80.3-1953. RIGID CON-DUIT ELBOWS, COUPLINGS, AND NIPPLES in a full range of sizes . are manufactured of the same fine high quality steel as RIGID CON-DUIT . hot dipped galvanized inside and out.

FLEXIBLE STEEL CONDUIT really flexible and crush-resistant for easier and faster installations • manufactured under Clifton's rigid controls from purchase of high quality steel tape to finished product • smooth inside surface assures you trouble free pulling during installation. Clifton Flexible Steel Conduit is approved by Underwriter's Laboratories, Inc. and conforms with Federal Specification WWC-556. Other quality products by Clifton: Bushed Armored Cable; Unarmored Service Entrance Cable; (CLIFTX) Non-Metallic Sheathed Cable; CLIFTALL-UF; Building Wire —TW, RHW, RR.

CLIFTON CONDUIT CORPORATION

A Division of General Cable Corporation 1 3300 Eastbourne Ave., Baltimore 24, Md.



### FRANK ADAM

NEW load centers take less space, give greater flexibility!



TWO BREAKERS IN SPACE OF ONE!

Smaller—more compact—Frank Adam's new line of circuit breaker load centers set the highest standards for safe, dependable lighting circuit protection.

Lugs on small main breaker can be used with either aluminum <u>or</u> copper conductors. Two capacities: 100-amps. for 12 or 20 branches—200-amps. for 20, 30 or 42 branches.

New duplex breakers permit future expansion, yet keep present space requirements to a minimum. Load centers are also available with new magnetic wound, copper coil, Quicklag breakers.

Sequence bussing . . . big gutters make wiring easy . . . competitively priced with fusible main equipment. In stock now at your wholesaler.

New Duplex Circuit Breaker is Frank Adam's space-saving secret. Capacities of 15 or 20-amperes—er a combination of both—use no more space than single pole breakers.

Color-coded handles give quick, easy and safe identification. Thermal magnetic...self-cleaning, contact wipe...tamper-poof calibration..."simul-tie" common tripping.

See our Catalog in SWEET'S



busduct · panelboards · s vilchboards · service equipment · safely switches · load centers · Quikheter

## WANT TO SAVE SOME MONEY?





I-T-E Urelite individually enclosed large air circuit breakers. Available up to  $600\,\mathrm{v}$  a-c,  $15\text{-}4000\,\mathrm{amp}$  continuous, up to  $150,000\,\mathrm{amp}$  interrupting.

### SAVE INSTALLATION EXPENSE

Look at that roomy cable box. I-T-E URELITE $_{\pi}$  gives plenty of elbow room to the men who install it. Easy to pull and connect even extra-large conductors. You can bring them in from either the top or bottom. This design means fast, easy, low-cost installation.



### SAVE MONEY WHEN YOUR LOAD GROWS

Want to increase the current rating of your URELITE breaker? Just reset the trip devices. It takes only minutes. Expanded ranges eliminate shutting down the circuit and replacing devices. Calibration is directly in amperes for easy, accurate setting.

Send for new illustrated Bulletin 4261-2b. I-T-E Circuit Breaker Company, Dept. SW., 1900 Hamilton St., Philadelphia 30, Pa.



## I-T-E CIRCUIT BREAKER COMPANY

Your guarantee of quality-

Triangle makes many types to one standard...

IT MUST BE RIGHT!



RUBBER &
THERMOPLASTIC
CABLES









INTERLOCKED
ARMOR CABLES







CONDUIT



AIRPORT LIGHTING CABLE
CAA Specification L-824
APPLIANCE WIRE
Thermoplastic, U/L
ARMORED CABLE
Type ACL, U/L
ARMORED LEAD CABLE
Type ACL, U/L
BUILDING WIRE
All Types, U/L

CATHODIC PROTECTION CABLE
Polyethylene Insulation, PVC Sheath
CONDUIT

U/L. Rigid Steel, Hot-Dipped Galvanized or black Enameled: Flexible Steel, Hot-Dipped Galvanized; EMT, Electro-Galvanized

CONTROL CABLES
IPCEA. Rubber, Thermoplastic or VC
Insulation; Braid, Neoprene,
Thermoplastic or Lead Sheath
FIXTURE WIRE

All Types, U/L
SUBMERSIBLE PUMP CABLE
Rubber Insulation, Neoprene Sheath
WEATHERPROOF LINE WIRE
Neoprene or Polyethylene Type
NON-METALLIC SHEATHED CABLES
Types NM, NMC-UF, U/L
PARKWAY CABLES

IPCEA. Rubber or VC Insulation; Lead or Neoprene Sheath; Flat, Plain Steel, Galvanized, or Steel Armor POWER CABLES

IPCEA. Rubber or VC, or Asbestos and VC Insulation; Braid, Neoprene Lead Sheath or Interlocked Armor SERIES STREET LIGHTING CABLE IPCEA. Rubber or Thermoplastic Insulation; Neoprene, Thermoplastic or Lead Sheath.

SERVICE CABLES
Service Entrance, Type SE Styles A, U.
Type USE, Style RR Service Drop Type SD,
Style SDC. Self-supporting Service Drop:
Neoprene or Polyethylene Insulation;
Rubber Insulation, Neoprene Sheath.
TREE WIRE
Rubber Insulated, Neoprene Sheath.

Wire • Cable Conduit • Plastic Pipe Brass and Copper Tube



TRIANGLE CONDUIT & CABLE CO., INC.

New Brunswick, N. J.

Manufacturers of Arteries for Electricity, Liquids and Gases

# Quiet...

### WAGNER Polyphase Resilient Mounted Motors in ratings through 10 horsepower

Quiet, vibration-free performance is essential when motors are installed in areas where noise must be held to a minimum . . . in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is needed or wanted.

Such installations have created a need for larger polyphase motors that whisper while they work. Wagner has met this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

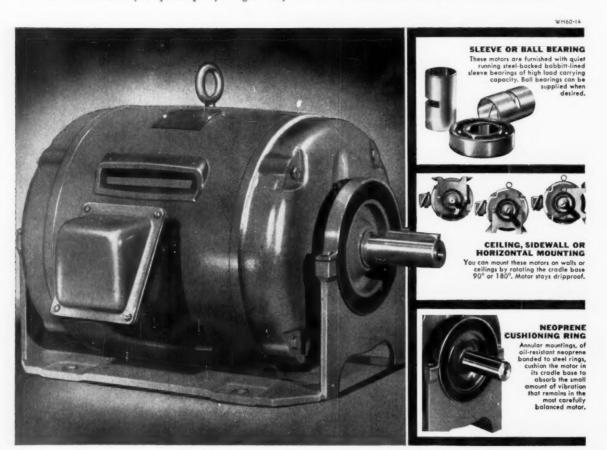
You certainly have applications that call for a smooth running motor, cushioned by resilient mountings. To make sure they're quiet, specify Wagner Polyphase Resilient Mounted Motors. Only Wagner can provide an entire range of ratings through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years...made the name Wagner one you can depend on in choosing electric motor drives.

Your nearby Wagner Sales Engineer can help you select the right motor to meet your requirements. There are Wagner branch offices in 32 principal cities.

### Wasner Electric Corporation

6413 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI



### ONLY

# HWBBRLL

MAKES RUGGED

# Twist-Lock



CAT. NO. **7313**3-WIRE CONNECTOR BODY
20 AMPS., 250 VOLTS, A.C. OR D.C.
10 AMPS., 600 VOLTS, A.C.



CAT. NO. **7311**3.WIRE CAP
20 AMPS., 250 VOLTS, A.C. OR D.C.
10 AMPS., 600 VOLTS, A.C.

Ever since it was first invented and introduced by Harvey Hubbell, Inc. back in 1930, "Twist-Lock" has provided greater convenience, safety and efficiency in the operation of motor driven tools and other portable electrical apparatus. The locking action insures positive contact in spite of rough treatment, heavy vibration and other conditions that might cause down-time.

Today, "Twist-Lock" is supplied in types, sizes and ratings to fit every industrial and commercial application. Units are available in 2, 3, 4 and 5-wire sizes. Every cap and connector body from 10 ampere to 50 ampere is available with "Seal-Tite" rubber covers for weatherproofing purposes, protection from dust and dirt, or from hard knocks and rough usage. Regular "Twist-Lock" units are supplied grounded and not grounded. Special noninterchangeable grounding types provide protection for 15 ampere, 125 volt or 277 volt applications.



### HARVEY

### HUBBELL

INCORPORATED

BRIDGEPORT 2, CONNECTICUT

In Canada: Scarborough, Ontario

# engineering news

HARVEY HUBBELL, INCORPORATED

**Engineering Department** 

"Twist-Lock" offers many wiring features which simplify installation, eliminate costly service call-backs, and provide dependable trouble-free life. The following are standard features of all regular "Twist-Lock" units:

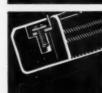
#### Heavy Duty Construction

SOLID BRASS MOLDED-IN INSERTS HOLD CONNECTOR BODY TOGETHER SECURELY



#### Trouble-Free Wiring

UPSET BINDING SCREWS CAN'T COME OUT!



#### "Bed-Rock" Blade Stability

BLADES SOLIDLY ANCHORED WITH MOLDED-IN KNURLED RIVETS LARGER SPUN-OVER AREA



#### "Speed-Easy" Wiring Convenience

HEAVIER SCREWS
LARGER BINDING
HEADS
TERMINALS RECESSED
IN CAP FOR EXTRA
WIRING ROOM



#### Armor Plate Protection

RUGGED STEEL ARMOR PLATE SHELL FOR MAXIMUM PROTECTION AGAINST BREAKAGE



#### Adjustable Cord Grip

HEAVY
ADJUSTABLE
CORD GRIPS
TAKE STRAIN
FROM
BINDING SCREWS



WHEN YOUR PLANT POWER SYSTEM needs additional capacity, capacitors offer an economical solution. By furnishing the magnetizing current that motors and other inductive loads need, capacitors reduce the current drawn from the power supply. Less current means less load on transformers and feeder circuits. Overload conditions can often be eliminated, and new loads can be served—all from a minimum investment in capacitors. To help you meet your expanding power needs economically . . .

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Your General Electric sales representative can help you determine the capacitors needed to economically solve overload problems and permit your system to serve new loads. Ask him for bulletin GEA-5632, for estimating capacitor kvar needed, and GEC-1331, for

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# ELECTRICAL CONSTRUCTION AND MAINTENANCE

### Men and Materials

Electrical construction is specific. It is never abstract. Electrical systems are useful only after specific products and workmanship have been selected, coordinated and competently applied. Electrical work installed in place is essentially irrevocable. A vast complex of decisions have to be made which must prevail for a substantial period of time.

Few people outside of the construction field can appreciate the details involved in the installation of even the most elementary electrical job. The assembly of products is almost deceptively simple in outward appearance. But each item has been expertly selected for a particular purpose or function. And each item is skillfully coordinated with all the other parts to which it is connected physically and electrically.

The physical assembly of an electrical system involves not only the selection and application of technical hardware, but skilled supervision and workmanship of a high order of competence. The installation must also satisfy exacting and often complicated rules, codes and standards.

Four years ago the editors of this publication produced for the first time, a comprehensive guide to modern electrical system design. Last year a major revision of the same project was presented and is now published as a hard-cover book. However, no comprehensive reference work of recent date has been available to this growing, expanding industry on the practice of electrical construction.

Today we are proud to present an entirely new, book-length, comprehensive, editorial feature devoted to the actual construction of electrical systems. The methods and practices described are fully up-to-date and practical. Special attention has also been given to compliance with the current (1959) edition of the National Electrical Code.

The project has been prepared by the same team of engineer-editors who produced "Modern Electrical Systems Design" (May 1959), and "Electrical Specifications" (May 1958). Every effort has been made to include the best and most representative current practice. Every effort has been made to be specific and to deal primarily with practical examples. We have attempted to fill a major gap in the literature of electrical construction. Your comments will be cordially welcomed.

Wm. T. Stuart



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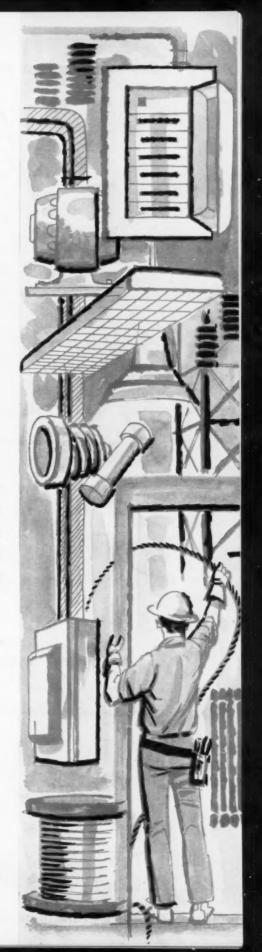
An original manual . . .

# Constructing Electrical Systems

A comprehensive report on the selection and installation of electrical equipment in modern systems for power, light, heat, signals and communications—with special emphasis on the requirements of the National Electrical Code covering placement, mounting and connecting of system components.

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# General

LECTRICAL construction consists in the selection and installation of physical equipment to fulfill the design of an electrical system. Simply stated, it is the execution of electrical design.

Any electrical system must first be designed to accomplish flow of current under controlled conditions of voltage and load. All characteristics of electrical circuits-resistance, reactance, impedance, normal currents, fault currents, voltages, power factors, demand load, regulation, capacities of component equipments-are evaluated and reconciled to design objectives. Then the purely electrical requirements must be translated into an installed system of actual materials, equipment and devices. Electrical hardware must do the electrical job and simultaneously measure up to certain physical requirements:

Its construction must first make it safe for use by minimizing the hazards of exposed live parts.

Its housing must protect it against accidental damage.

Its insulation must assure reliable separation between live parts and non-current-carrying metallic parts.

Construction must suit equipment to particular severity of duty—use in hazardous, wet, contaminating or corrosive atmosphere; use at temperature extremes; frequent operation of moving parts; exposure to electrical transients and overloads; exposure to thermal and magnetic stresses of short-circuit faults at point of application; continuous operating duty.

Equipment must be suited to the mounting and/or suspension method used. Physical size must be related to space requirements. Weight must be checked against strength of floor or wall or other structural bearing part.

# Considerations

Place of installation must also be considered. Major distribution elements—transformers, panels, regulating equipment — should be grouped for ready maintenance. In commercial and institutional interiors, equipment should be concealed as much as possible. And where necessary, equipment operating noises—transformer hum, relay and contactor chatter, ballast hum, noise of rotating equipment—must be isolated by means of special mounting methods or by sound-proof enclosure.

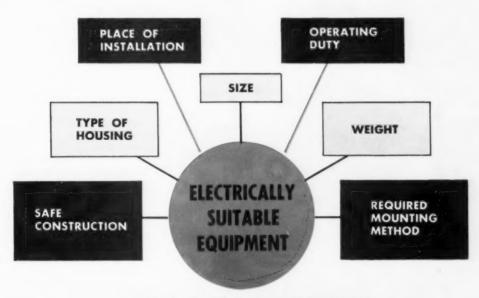
These and many other purely physical considerations must be carefully correlated with the purely electrical requirements of any electrical system. But there are a number of general considerations which should be made prior to start of electrical work. These involve the general responsibilities of the in-

staller and outline his correlation to other contractors and to the architect or engineer.

Electrical construction work should always be carefully coordinated with structural, architectural and mechanical work. On new construction or modernization work. the installer should examine the relation of electrical work to that of other trades, to determine if there are any conditions which would interfere with perfect workmanship by the electrical installer. Where the electrical installer works in conjunction with installers of plumbing, heating, ventilating and/ or air conditioning equipment, he should fully understand the nature and extent of their work as set forth in any plans or specifications.

The electrical installer should also establish a fixed sequence of operations on any job, scheduling his work progress to correspond with proper stages of other construction. Roughing-in, embedding of conduit in concrete, recessing of lighting fixtures, and other steps in electrical work must be done in proper time relation to structural, concrete, lathing and plastering work. Such a schedule will assure a uniform rate of progress, without holdups and hurry-ups for any trade.

Another important general consideration in electrical construction is checking of space requirements. Plans and specifications should be carefully checked against the actual building as it is constructed, to insure that sufficient space is available for switchboards, panels, transformers, conduits, busway, and other electrical hardware. Specific equipment locations should be verified on the job. Problems in this



SELECTION AND INSTALLATION OF EQUIPMENT ARE RELATED TO MANY PHYSICAL FACTORS

#### General Code Rules on Electrical Construction

1. Conductors and equipment are acceptable for use under code regulations only when approved by the authority enforcing the code. Approval, therefore, does not require listing by the Underwriters' Laboratories; although an individual inspector might base his acceptance on such listing.

2. Suitability of equipment—materials, devices, fittings, apparatus and appliances—for use under the code is based upon—

a. Conformity with code provisions.

 Mechanical strength and durability, including adequate protection by enclosures or housings.

c. Effective electrical insulation.

 Heating effects under normal and abnormal conditions of use.

e. Arcing effects.

3. Current-interrupting devices—switches, relays, contactors, fuses and circuit breakers—must have sufficient capacity and strength to safely perform their current-breaking tasks. For switching devices, this means ability to interrupt normal load currents and any overload or fault currents which the device might be called upon to break. For an overcurrent protective device, this means ability to interrupt fault currents which could occur at the point of application of the device, without damaging or destroying itself in the act of interrupting. In particular, this means that short-circuit protective devices must be rated in interrupting capacity to safely break the maximum current which the circuit can deliver into a bolted short on its load terminals.

An exception to this requirement on current-interrupting ability is made in the case of isolating switches which are designed to isolate a circuit after the load current has been interrupted by some other device.

**4.** In deteriorating atmospheres—damp or wet locations or where gases, fumes, vapors, liquids or other agents which have a deteriorating effect are present—electrical equipment must be approved for the conditions of application.

5. Electrical equipment must be firmly secured to

the surface on which it is mounted.

**6. Suitable working space** must be provided and maintained about all electrical equipment. Working spaces adjacent to exposed live parts must not be used as passageways or for storage.

7. Exposed live parts of equipment operating at 50 volts or more shall be guarded against accidental contact by enclosure or by locating the equipment—

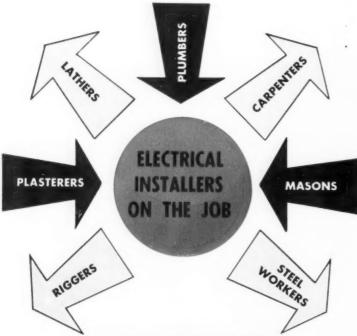
 a. In a room or enclosure accessible only to qualified persons;

 On a balcony, gallery or platform, elevated and arranged to exclude unqualified persons;

c. Elevated 8 ft or more above the floor;

d. So that it will be protected by a guard rail if the equipment operates at 600 volts or less.

8. Maker's name, trademark or other identification symbol must be placed on all electrical equipment. Other markings must be provided giving voltage, current, wattage or other ratings as prescribed in specific sections of the code.



COORDINATED WITH OTHER TRADES
ELECTRICAL WORK MUST BE CAREFULLY

matter should be carefully anticipated and solved. As necessary, the electrical installer should work closely with other installers and with the architect or consulting electrical engineer.

Other common rules which are applied to electrical construction are as follows:

 As far as possible, use standard equipment to facilitate later maintenance of the system.

Cooperate fully with any and all inspection authorities.

 On all changes from plans and specifications, check with the architect or engineer before commencing work and obtain written confirmations.

4. Obtain written approval before purchase and installation of any and all equipment for which the specifications require approval and for any equipment which is a substitution in make or type for that specified.

5. Observe National Electrical Code rules and any local or special code rules on installation of electrical equipment. 6. Obtain any required shop drawings of equipment and submit them to the architect or engineer for approval, as required in the plans or specifications.

7. Carefully read and fully understand any spec requirements on testing systems and components for

shorts and grounds.

8. Keep a running record of all changes and revisions in original design and record these on a set of original cloth drawings.

9. Obtain and pay for all permits necessary for performance of the job and pay all costs for inspections and certificates.

10. Use the Underwriters' Lab-

oratories' lists of acceptable equipment in selecting equipment for the electrical system.

11. Provide on-the-job housing or other protection against loss or damage for all equipment and material delivered to the site of work.

12. Upon completion of electrical construction work, clean all exposed conduit, fittings, fixtures, equipment, and accessories of all dirt, mortar, grease, oil, stains or other surface imperfections. Remove paint spots or runs.

Of course, the foregoing requirements will vary from job to job. Large jobs are different than small jobs. Modernization work differs

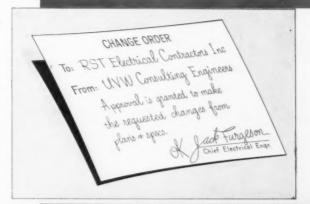
from new construction. The installer must adapt his performance.

The following pages present a comprehensive analysis of electrical construction. Tested trends of particular merit are highlighted. National Electrical Code rules are summarized and illustrated. To provide ready reference to this data for day-to-day design and construction work, the presentation is broken down according to basic product types. First, utilization equipment is covered. Then, the common elements of electrical distribution are treated in sequence. Finally, categories of special equipment and systems are studied.

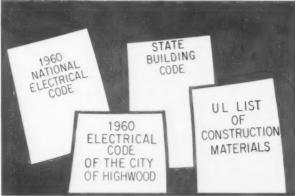
# SCHEDULE OF JOB OPERATIONS ASSURES STEADY WORK PROGRESS

CHANGES FROM PLANS AND SPECS MUST BE CLEARED WITH THE ENGINEER AND/OR ARCHITECT

			EN				DEPAR		IT.			
Job No.	Name	Eng. in Chge	Georgia I				Permit				Partial Billing	
8694	Goliseum	Peters	V	V	V	8/59	Yes	Yes	Oct 1	Jones	90%	Check
8805	Green	#	V	V	1	7/59	Yes	Yes	June 15	Clark	30%	
375	Merch Pk	-11	V	V	1	6/59	Yes	10%	Feb 6	Dixon	85%	Check
8750	Kirby	Ross	V	1	V	9/59	Yes	80%	Nov 10	Ross	70%	Check
215	4+4	Peters	1	V	V	7/59	Yes	50%	Dec 1	Smith	30%	
8765	Lawson	Ross	V	V	1	10/54	1	60%	Dec I	Clark	30%	
453	Bake Oil	"	V	V	1	8/59	1	10%	Jun 1	Jones	None	
450	Dixon	Peters	V	1	1	8/59	Yes	50%	Mar 15	Clark	25%	









# Luminaires and Lighting Equipment

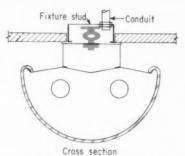
HE PROBLEM of code compliance on luminaires and lighting equipment is a joint problem shared by the installing electrical contractor and by the lighting equipment manufacturer, or manufacturers. This joint responsibility is brought about through certain code requirements which hinge on equipment design and construction, such as operating temperatures of lighting units in contact with structural materials, or metal gages and wire sizes, etc., which are covered in the code. Thus certain code requirements can be fulfilled, practically only by the manufacturers. On the other hand, the electrical contractor has the ultimate responsibility for complying with the code, and he must therefore see to it that any and all lighting units or lighting equipment installed on his jobs meet all the applicable code requirements. He must further be sure that installation techniques used in installing the lighting units and equipment comply with all other applicable code requirements.

This responsibility poses no particular hardship on the electrical contractor, since he is a specialist in this field of electrical construction work in the first place, and usually knows quite well the local electrical inspector who must inspect and pass on the compliance of the installation with the applicable code rules. Thus, if a new type of unit is used on a job, or a new installation technique seems indicated, the electrical foreman is well advised to discuss it in detail with the inspector before proceeding with the work.

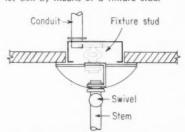
The number of ways of installing luminaires and lighting equipment, al' in accord with the code requirements, are many. Each electrical foreman usually has his own special methods which he uses. Presented herein are some typical installation methods, and mounting techniques. These are not intended to be all-inclusive, but are considered more or less typical of the various techniques being used.

#### Surface Mounted Luminaires

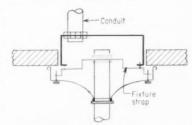
Through the 80-year history of the electric lighting industry, most



SURFACE MOUNTED fluorescent luminaire is attached to rigidly-supported outlet box by means of a fixture stud.



**PENDANT MOUNTED** luminaire is attached to fixture stud in outlet box, which is a typical mounting method.



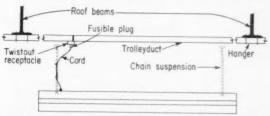
**LIGHTWEIGHT LUMINAIRES** may be attached to the outlet box by means of a fixture strap.



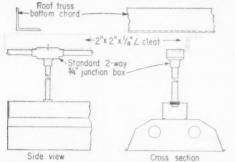
FLUORESCENT LUMINAIRES usually require more than one point of support, and mechanical support is therefore provided by structural means at points other than outlet boxes.

luminaires and lighting units of the permanently installed type have been surface mounted on ceiling or wall outlets. Thus the methods used have become more or less universal.

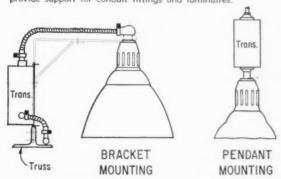
The introduction of fluorescent lamps and luminaires more than 20 years ago brought about the need for certain new installation and mounting techniques. Luminaires have become too large and too bulky for mechanically safe mounting from an individual electrical outlet. Also, the use of continuous row equipment further outmoded the practice of supporting equipment from outlet boxes only. Various mechanical methods have been developed, ranging from a lag-bolt embedded in a concrete slab ceiling, to trolley ducts and fittings.



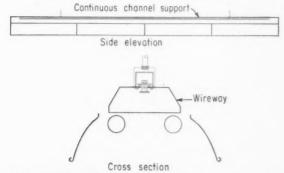
**TROLLEY-DUCT** attached to bottom of roof beams provides both electrical service and means of mechanical support.



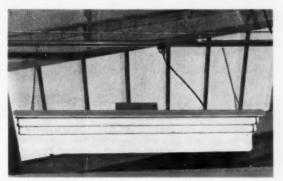
**ANGLE IRON** sections attached to bottom chords of roof truss provide support for conduit fittings and luminaires.



**MERCURY REFLECTOR** units and necessary accessory transformers may be mounted in a variety of ways. Typical bracket and pendant mounting methods are shown here.



**CONTINUOUS STEEL** channel provides continuous line of support for industrial fluorescent luminaires, and may be supported by rod from ceiling structure at unequal spacing points.



**TROLLEY-DUCT** may be supported by suspension cable which is partly rod-supported from ceiling.

#### GENERAL CODE REQUIREMENTS

The National Electrical Code requirements relating to the physical installation and electrical connection of luminaires (lighting fixtures) and lighting equipment are mainly practical and reliable techniques designed to provide minimum safety and protection against electrical hazards and electrically-caused fires. Only some of the more general requirements are presented and discussed here; the complete requirements are given in Article 410 of the National Electrical Code.

Generally, code requirements for lighting units may be considered as those requirements usually considered as structural and electrical practices deemed necessary for safe and reliable operation. Specific code requirements must be followed in all instances wherever they apply. These specifics, however, will usually be fulfilled if the general practices outlined below are followed.

 Install and mount all luminaires and lighting equipment according to usual structurally-sound principles and practices.

2. Install all lighting units in such manner that heat will be dissipated rapidly, and does not concentrate in small areas (in excess of 90° C, or as required by the code).

 Select and use only luminaires and lighting equipment which are structurally well designed and constructed, and which use quality parts and materials throughout.

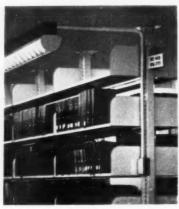
4. Use only approved types and sizes of wire, and be sure that all live terminals, parts, junctions, etc. are properly taped and covered and otherwise concealed from access by unauthorized persons.

5. When installing recessed types of lighting equipment, be sure that equipment is well ventilated, and is not installed in space which will become a dead air pocket, or which will otherwise contribute to operation in excessively high temperatures.

If these five general rules are followed in the mounting and installation of lighting units, both in concept and specifically, most of the applicable code requirements will be met automatically. It is important, however, that all local and national code rulings be known and observed. Thus all code requirements should be studied and followed wherever they apply specifically.



**WALL URNS** are attached to brick columns by means of lag screws, and lead sheathed cable is run exposed on brickwork to supply power to units.



**CONTINUOUS ROW** single-lamp fluorescent luminaires are attached directly to surface-mounted raceway to light library stack shelves. Switch leg is run in conduit.



**SPOTLIGHT** on adjustable bracket arm is mounted on trolley duct by means of special plug, receptacle fittings—may be used in show windows and elsewhere.

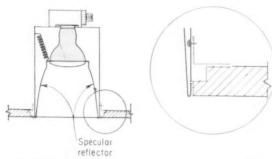
#### **Recessed Incandescent Luminaires**

The trend to the mounting of lighting units flush in the ceiling began back in the mid-1930s, or about 25 years ago. Introduction of reflector-type spot and flood lamps in the late 1930s, and the subsequent design of metal housings for these lamps, dubbed "high hats" because of their typical shape, sharply spurred this trend which

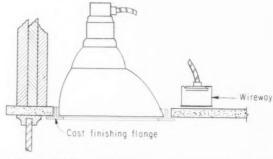
has continued to the present time.

Installation techniques for recessed incandescent units vary in detail from one manufacturer's product to another, and according to type of ceiling construction. The basic principle for all units, however, is the same. A metal housing holds the lamp, and such accessories as louvers, baffles, lenses, color

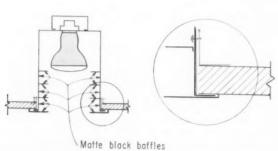
rings, etc. A plaster ring, or ceiling flange of some type, is used to provide a suitable opening for the metal housing, which in turn has a provision for attaching it to the building structure by means of bolts, screws, clips, flanges, or otherwise. Some typical installation techniques are shown in the accompanying photographs.



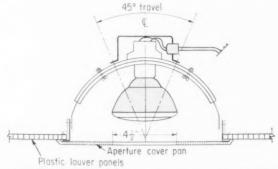
LOW-BRIGHTNESS reflector unit for spot or flood reflector lamp is mounted flush in ceiling, using flangeless construction, by means of mounting angles which rest on single plaster ring.



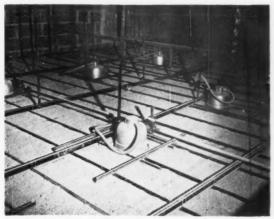
**SHOW WINDOW REFLECTORS** are recessed simply by allowing unit to rest on a cast finishing flange. Flexible conduit length is used between reflector socket and wireway nearby.



**BAFFLE-RING** unit is recessed flush in ceiling by means of simple brackets end screws, and opening is given a finished appearance by simple aperture plate.



ADJUSTABLE SPOTLIGHTS can also be recessed, and unit here is shown mounted flush in a plastic louver panel. Unit has a  $45^\circ$  travel.



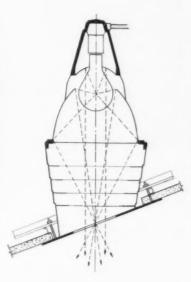
**PLASTER RING** and furring channel are used to support this recessed incandescent housing in a plaster ceiling.



**SPECIAL U-CHANNEL** framing was used to provide suitable support for a large 500-watt unit recessed in ceiling.



**BOTH WIRING** and mounting details are shown here, where units are recessed in space adjoining a catwalk.





ATTIC VIEW shows mounting details for ellipsoidal reflector installed in a horizontal ceiling. Note the use of bent angle iron, and strap iron mounting clips.

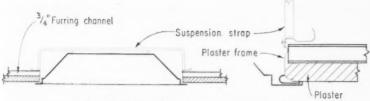
**ELLIPSOIDAL REFLECTORS** are often used for lighting high ceiling areas in commercial or public structures, and can be installed flush in either horizontal or angle ceilings.

#### Recessed Fluorescent Luminaires

Fluorescent luminaires are inherently large and bulky, because of the nature and shape of fluorescent lamps with which these units are designed to be used. Also, modern lighting levels require a large number of lamps to provide the amount of light needed. With all these luminaires exposed in the areas which they are to light, a very cluttered appearance results. Because of this, and also because of a growing trend to combine light and architecture, structurally and design-wise, much of the fluorescent lighting being installed today is of the recessed type. Methods used to recess fluorescent luminaires vary greatly. Some of the construction and mounting methods are shown in accompanying photos.



WIRING connections in attic space are shown for 2-ft-sq fluorescent units, recessed flush in a plaster ceiling.



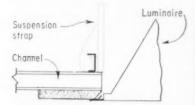
#### SUSPENDED PLASTER CEILING MOUNTING

**PLASTER FRAME** provides clean opening for recessed fluorescent troffer in plaster ceiling. Suspension straps attached to furring channels support troffer and hold it rigidly in place.



LUMINAIRE SUPPORTED ON GRID TEE ACOUSTICAL CEILING CONSTRUCTION

**TROFFERS** lay in place easily and are supported by grid tee acoustical ceiling construction.

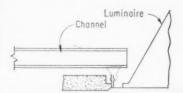


## ACOUSTICAL CEILING MOUNTING WITH CONCEALED SUSPENSION

**TROFFERS** will also fit snugly into acoustical ceilings using concealed suspension mounting. Troffers attach to suspension strap which is supported by U-channel.



**SUSPENSION** and wiring details for a typical 4-lamp 24-in, wide shallow troffer unit are shown in this view. JB is accessible when fixture is lowered.



#### TEE-BAR CONSTRUCTION SUP-PORTS CEILING AND LUMINAIRES

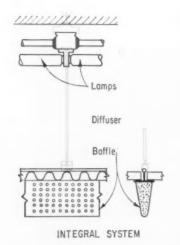
**TEE-BAR** construction is another typical method used for supporting acoustical ceiling panels, and troffer units are made by some lighting manufacturers.

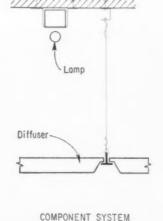
#### Diffuser Ceiling Lighting

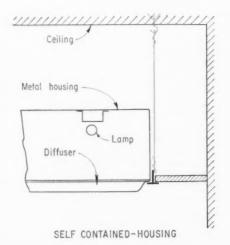
A major lighting trend over the past decade has been that of diffuser ceiling lighting, including systems which use both diffuser and louver ceiling panels. This type of lighting goes beyond the concept of recessed lighting systems. Like recessed lighting, however, all of the equipment is installed above the

ceiling. Its difference is that the ceiling itself becomes part of the lighting system in a system of diffuse ceiling lighting.

There are many manufacturers of diffuser ceiling lighting systems, and each producer usually has his own installation methods and techniques, in some cases based upon the use of patented devices and accessories. Here too, however, the installation techniques can be classified in general under three broad types. These three types are illustrated by the accompanying drawings. Manufacturers of specific types of ceilings will gladly supply installation and mounting details.

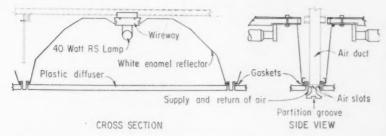






#### THREE TYPICAL INSTALLATION METHODS FOR DIFFUSER CEILING LIGHTING SYSTEMS

**DIFFUSER CEILING** lighting systems are classified according to one of three basic types, as illustrated above. These basic types are based on installation techniques and methods of support, primarily, as indicated.



MULTI-FUNCTION LIGHTING SYSTEM-PROVIDES LIGHT, DISTRIBUTES
AIR, BLOCKS SOUND, ANCHORS PARTITIONS

**MULTI-FUNCTION** lighting systems are a refinement of the idea of diffuser ceiling lighting, and provide light, distribute air, block sound, and anchor partitions, as indicated in this drawing. Entire system, except for air ducts, is made and supplied by lighting equipment manufacturer, and installed by the electrical contractor.





**COMPONENT** diffuser ceiling system is of simple construction, and consists of diffusers, diffuser panel T-tracks, wireway strips, and support rods or wire. Electrical connections are made at end of wireways, as shown.

INTEGRAL diffuser ceiling lighting system consists of wireway housing modular grid framework, sound baffles between modules, partition or acoustical baffle grooves, air diffuser outlets, and sprinkler outlets. Entire ceiling goes up as an integral structure.

## Large Area—Low Brightness Luminaires

A compromise approach to lighting design between individual luminaires or continuous row narrow units on the one hand, and overall wall-to-wall luminous ceilings on the other hand, is that of large area units of low surface brightness, such as 4 ft by 4 ft and larger, but not wall-to-wall. These large area units may be suspended, surface mounted on the ceiling, semi-recessed, or fully recessed flush in the ceiling.

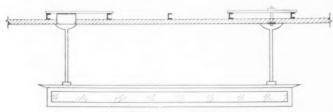
Mounting methods for these large-area units vary, but in general the units are supported at four or more points, and suitably connected directly to the structural members of the ceiling by one method or another. Typical details are shown in the accompanying sketches and photos. In general, manufacturers cooperate with the electrical contractors in providing suitable means for supporting the units properly and in an approved manner.



MODULAR 4-ft-sq luminaire is hoisted in place by means of electric hoist. Metal housing will be attached to bracket clips shown exposed in ceiling opening.



SURFACE INSTALLED ON CEILING



SUSPENSION MOUNTED

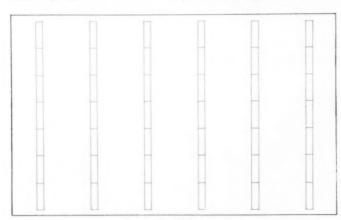


SEMI-RECESSED IN CEILING



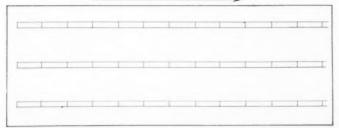
FLUSH RECESSED IN CEILING

**FOUR METHODS** for installing large area - low brightness luminaires are shown in this drawing—surface mounted, suspended, semi-recessed, and recessed. Suitable means must be provided in each type of mounting to adequately support the luminaire directly from the ceiling structure.



Troffers with 35°/25° shielding

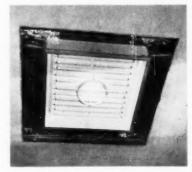
DIRECTION OF VIEWING



Troffers with 35°/45° shielding



**CAVITY** in ceiling serves as reflector for this large area - low brightness unit. Metal frame supports diffuser panel, and has suitable finish for ceiling opening.



HOUSING for combination incandescentfluorescent luminaire is held in place by rads anchored in ceiling slab above. A regressed-finishing flange will provide concealment of space between housing and ceiling line.

# Lighting Maintenance Provisions

Many lighting installations are of such nature that provisions must be made for cleaning and relamping the equipment at the time of installation. This is especially true

**ORIENTATION** of luminaires is a problem which always faces the lighting designer, or the electrical contractor when the lighting layout has not been detailed.

In offices, drafting rooms, classrooms, and similar areas, when opaque-sided luminaires are being installed, it is preferable to orient the units so that occupants face the side with the greatest shielding. Luminaires with luminous sides should generally be installed so that they are viewed lengthwise.

In the illustrations to the left if occupants face lengthwise (see arrow) in the room, opaque-sided luminaires with 35/25 shielding should be installed crosswise in the room so that workers will face the side with the 35 degree shielding. If the units have 35/45 shielding, install them lengthwise so that the 45 degree shielding will normally be viewed.

When continuous row equipment tends to produce too much of a "bowling alley" effect, the rows can be broken.

of high bay lighting jobs, and of ceiling-recessed equipment which is to be serviced from above the ceiling. However, maintenance provisions should also be considered for every lighting installation, and installed whenever it is indicated that economies would result from such provisions. Some of the things that can be done include the use of disconnect devices and lowering devices for hard-to-get-at lighting units, installation of catwalks, and walkways adjacent to lighting units and such methods as shown at right.

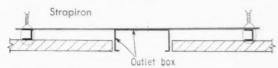


MAINTENANCE of lighting equipment is simplified by a trolley-mounted cage which provides access to any point in the equipment-stuffed area.

#### CODE RULES ON LIGHTING EQUIPMENT

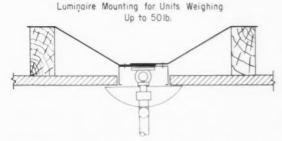
 Luminaires, lampholders, rosettes and other lighting equipment must be securely supported.

Outlets for luminaires shall be designed for the purpose, and outlet boxes and fittings which are firmly secured to the building construction, such as concrete, masonry or other building material, are considered as securely fastened.



Any luminaire may be attached to an outlet box where the box will provide adequate support, but units which weigh more than 6 lbs, or exceed 16 in. in any dimension, shall not be supported by the screw shell of a lampholder.

A normal method of securing an outlet box in place is to use strap iron attached to back of outlet box and fastened to studs, lathing channels, steel beams, etc. nearby. Light weight units are sometimes attached to outlet box by means of screws through luminaire canopy which thread into outlet box ears, or flanges, tapped for this purpose. For heavier luminaires, fixture studs, hickeys, tripods or crowfeet are normally used.

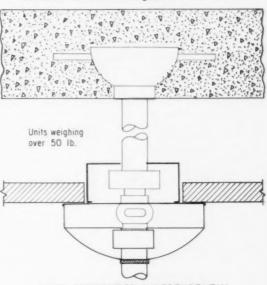


OUTLET BOX RIGIDLY SUPPORTED

A luminaire which weighs more than 50 lbs must be supported independently of its outlet box.

Various techniques are used for mounting luminaires independently of the outlet box, depending somewhat on the total weight of the individual luminaires. In general, pipe or rods are usually used to attach the luminaires to the building structure, and the electrical circuit is made by using flexible armored cable between the luminaire and the outlet box concealed in the ceiling cavity. If provision is made for lowering the luminaire, by

means of winch or otherwise, provision must also be made for disconnecting the electrical circuit.

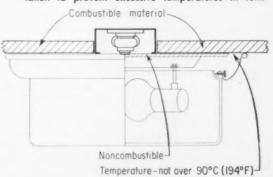


UNIT SUPPORTED INDEPENDENTLY

#### OF OUTLET BOX

- Luminaires, lampholders, lamps and rosettes shall have no live parts normally exposed to contact.
- Luminaires shall be so constructed and so installed that, when near combustible material, this material will not be subjected to temperatures in excess of 90° C (194° F).

The NECode requires that various precautions be taken to prevent excessive temperatures in lumi-

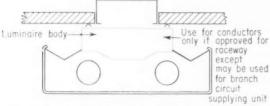


naires, outlet boxes, and in proximity with combustible materials. Luminaire construction and method of installation shall be such that conductors in outlet boxes shall not be subjected to temperatures greater than that for which the conductors are approved. Where a fluorescent luminaire, containing a ballast is to be installed on combustible low-density cellulose fiberboard it shall, where surface mounted: 1) be approved for this condition, or 2) be spaced not less than 11/2 in. from the surface of the fibreboard.

6. Wiring conductors in luminaires shall not be smaller than No. 18, and shall be so arranged that they are not subjected to temperatures above those for which they are approved, based on type of insulation used on the conductors.

7. Luminaires shall not be used as a raceway for circuit conductors unless the luminaires meet the requirements for approved raceways. The conductors of the single branch circuit supplying the luminaires may, however, be carried through luminaires approved for end-to-end assembly to form a continuous raceway.

Most self-contained fluorescent luminaire units now available are designed for end-to-end assembly. Each luminaire contains a metal body, or housing, which serves as the structural member of the luminaire and provides a housing for the ballast, wiring, etc. which is of sufficient size to permit running the branch circuit wiring through the unit. Each luminaire is then tied to the branch circuit by means of a single tap. When approved as a raceway, any number of branch circuit conductors may be installed within the capacity of the raceway. When housings are approved as raceways, luminaires carry an Underwriters' Laboratories label which states "Fixtures Suitable for Use as Raceway."

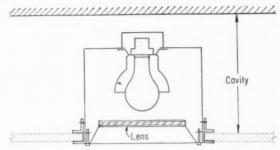


 Luminaires shall be constructed of metal, wood, or other approved material, and shall be so designed and assembled that they are adequately strong and rigid.

 Resistors or regulators for mercury-vapor lamps shall be enclosed in noncombustible cases, and treated as sources of heat.

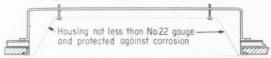
 Luminaires which are installed in recessed cavities in walls or ceilings shall be so constructed that adjacent combustible material will not be subject to temperatures in excess of 90° C (194° F).

Heat is a major problem in lighting system design, and with the trend to the use of recessed luminaires and equipment, the problem is increased. In the case of luminaires using incandescent lamps, the problem is primarily the prevention of concentrated spots of heat coming into contact with the building structure. In the case of fluorescent luminaires, the major heat problem is related to the ballast, which can build up severely high temperatures when not properly ventilated, or designed for cooler operation through adequate radiation and convection. These are problems which must be solved 1) through proper luminaire design, and 2) through proper installation methods and techniques.



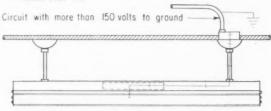
Luminaires shall not subject adjacent combustible material to a temperature in excess of 90°C (194°F).

 Sheet metal enclosures for recessed luminaires shall not be less than No. 22 USS gauge, and shall be suitably protected against corrosion.



12. Metal luminaires, transformers and transformer enclosures on circuits operating at more than 150 volts to ground shall be grounded

In general, all lighting equipment and luminaires must be grounded. Such luminaires and equipment shall be considered as grounded where mechanically connected in a permanent and effective manner to metal raceway, the armor of armored cable, the grounding conductor in non-metallic sheathed cable, or to a separate grounding conductor not smaller than No. 14.



METAL LUMINAIRE, TRANSFORMER AND TRANSFORMER ENCLOSURE MUST BE GROUNDED.

13. Voltage to ground on branch circuits supplying luminaire outlets and lighting equipment outlets shall not exceed 150 volts, except 1) in industrial establishments the voltage of branch circuits which supply luminaires mounted not less than 8 ft from the floor and which do not have integral switch control, shall not exceed 300 volts to ground, and 2) in industrial establishments, office buildings, schools, stores, and public and commercial areas of other buildings, the voltage of branch circuits which supply only the ballasts for electric discharge lamps in permanently installed luminaires mounted not less than 8 ft from the floor, shall not exceed 300 volts to ground.

14. A temperature higher than 90° C (194° F), but not higher than 150° C (320° F), is acceptable where a luminaire is recessed in fire-resistant material in a building of fire-resistant construction, if the luminaire is plainly marked that it is UL-approved for that service.

15. Lighting coves shall have adequate space and shall be so located that lamps and lighting equipment and accessories can be properly installed and maintained.

# **Motors and Controllers**

ACTORS which must be considered in choosing a motor for a specific application include (1) electrical supply; (2) horsepower, torque and speed; and (3) motor enclosure.

(1) Alternating current is used predominantly today, although the trend to automation and the resulting need for wider speed ranges has brought back dc motors to many plants. In general, however, the cost of dc motors and associated equipment will usually dictate use of ac components where no unusual requirements are involved. Use of single phase or polyphase supply and motor sizes and designs available in each type will influence the choice. Special functions favoring high-cycle operation may require conversion equipment for use on standard 60-cycle lines. Certain motors are affected more than others by variations in line voltage and frequency; hence system stability should be investigated.

(2) Horsepower, torque and speed are inter-related, one affecting the other. Characteristics of the driven load and its power requirements must be known. For maximum economy in cost and space, it is important that motor size be no greater than demanded by the load and duty cycle. On the other hand, an undersized motor will have a reduced life expectancy

due to overloads. Where equipment manufacturer load data is not given, tests must be made to determine torque requirements. If the load varies during normal operation, the effective horsepower must be determined taking into consideration the duty cycle, the effective horsepower being that load which would produce the same temperature rise under continuous operation.

(3) Motor enclosures protect the motor's parts from external damage and contaminants as well as the operating personnel from conditions arising due to motor failure. The specific application and nature of any contaminants present will dictate the best enclosure for the job. NEMA Standard MG-1-1.21 defines standard enclosures (see accompanying box for summary).

Moisture problems require special consideration. Suitable guards or enclosures must be provided to protect exposed current-carrying parts of motors and the insulation of motor leads where dripping or spraying oil, water, or other injurious liquid may occur, unless the motor is specially designed for the existing conditions (NEC Sec. 430-11).

Such contaminants may be encountered both indoors and outdoors. A motor having an enclosure designed for the purpose is to be

## NEMA Designs

(Polyphase Squirrel Cage Induction Motors)

- Design A: Locked-rotor current is higher, locked-rotor torque is the same, and break-down torque is higher than standard Design B Motors.
- Design B: Characteristics, used as a standard for comparing those of other types, are suitable for most applications.

  Efficiency is relatively high; power factor is good at full load.
- Design C: Locked-rotor torque is higher, break-down torque is lower, and locked-rotor current and slip are the same as Design B motors. Efficiency and power factor are sacrificed to some extent to achieve higher initial torque on starting.
- Design D: Torque and slip are high, useful for loads involving high inertia and frequent load changes.
- Design F: Both torque and starting current are low.



preferred, especially outdoors, where winds, driving rain, etc., may penetrate other makeshift enclosures. Where the condition is not severe, such as encountered in the vicinity of spray-producing industrial machines or a dripping water pipe, a sheet metal enclosure over the motor, a baffle between the motor and source of injurious liquid, or a shield to channel off the drippings may be used.

Failure to observe these precautions is likely to result in absorption of moisture by the motor windings, followed by lowered insulation resistance and ultimate breakdown, with fire as an ever-present hazard.

The best of shields may not prevent condensation of moisture within the motor enclosure, with breakdown possible even under subsequently dry conditions. Such condensation also encourages bearing oxidation with a resultant reduction in the useful life of the bearings.

Motor enclosures available for such applications include dripproof and splashproof types. Where general purpose or dripproof motors are operated intermittently, Class A insulation will help combat humidity conditions. For standby service, or for damp-location operation, a low single-phase voltage (on the order of 5 to 10% of rated voltage) is sometimes applied to the windings to combat moisture. Some larger motors are available with built-in strip- or tubular-type space heaters for this purpose. Where such motors may be exposed intermittently to heat from other sources, such as direct sunlight, the heater should be thermostatically

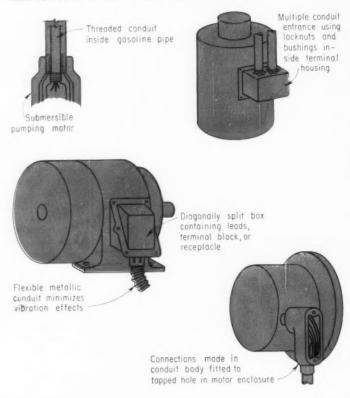
Motors must be located so that adequate ventilation is provided and so that maintenance such as lubrication of bearings and replacing of brushes can be accomplished. Open motors having commutators or collector rings must be located or protected so that sparks cannot reach adjacent combustible material (NEC Sec. 430-14). This does not preclude the mounting of such motors on wooden platforms or floors. Where other combustible material must necessarily be placed close by, hinged or removable sheetmetal shields may be used to contain the sparks.

#### Hazardous Locations

Motors suitable for hazardous locations are tested and listed by

#### MOTOR TERMINAL HOUSINGS

Terminal housings for making connections to branch-circuit and control conductors are usually furnished with the motor. These outlet boxes or conduit boxes must be of ample size to make connections properly and must be of substantial metal construction (NEC Sec. 430-12). Some motors are provided with a tapped hole in the enclosure to receive a conduit body or fitting, in which case the size of the hole will determine the size of fitting to be used. Some smaller motors use only bushings to protect the supply cord where it passes through the frame of the motor. Where such motors may be exposed to oils, grease, oily vapors, or other substances having a deleterious effect on rubber, bushings other than soft rubber must be used (NEC Sec. 430-13).



#### HAZARDOUS LOCATIONS: NEC DEFINITIONS

#### CLASS I

Group A: Atmospheres containing acetylene.

**Group B:** Atmospheres containing hydrogen, or gases or vapors of equivalent hazard such as manufactured gas.

Group C: Atmospheres containing ethyl-ether vapors, ethylene, or cyclo-propane.

Group D: Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors, or natural gas.

#### CLASS II

Group E: Atmospheres containing metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.

Group F: Atmospheres containing carbon black, coal or coke dust.

Group G: Atmospheres containing flour, starch, or grain dusts.

#### OPEN

General Purpose: Ventilating openings permit passage of external cooling air over and around the windings of the machine.

**Dripproof:** Ventilating openings are so constructed that drops of liquids or solids falling on the machine at any angle not greater than 15 degrees from the vertical cannot enter the machine either directly or by striking and running along a horizontal or inwardly inclined surface of the machine.

Protected (Guarded): Openings giving direct access to live or rotating parts (except smooth shafts) are limited as to size by the design of the structural parts or by screens, grills, expanded metal, etc., to prevent accidental contact with such parts.

Splashproof: Ventilating openings are so constructed that drops of liquid or solid particles falling on the machine or coming toward the machine in a straight line at any angle not greater than 100 degrees from the vertical cannot enter the machine either directly or by striking and running along a surface of the machine.

Pipe (Forced) Ventilated: Openings for admission of ventilating air are so arranged that inlet ducts or pipes can be connected to them.

Weather-Protected: Type 1: Ventilation passages are so designed as to minimize the entrance of rain, snow and airborne particles to the electrical parts. Type II: Ventilating passages at intake and discharge are so arranged that high-velocity air and airborne particles blown into the machine by storms or high winds can be discharged without entering the internal ventilating passages leading directly to the electric parts.

#### TOTALLY ENCLOSED

Nonventilated: Not equipped for cooling by means external to the enclosing parts.

Fan-Cooled: Equipped with exterior cooling by means of a fan or fans, integral with machine, but external to its enclosing parts.

Pipe-Ventilated: Openings for admission of ventilating air are so arranged that both inlet and outlet ducts or pipes can be connected to them.

Heat Exchanger Type: Cooled by circulating the internal air through a heat exchanger, which in turn is cooled by external air or water.

Explosion-proof: Designed and constructed to withstand an explosion of gas or vapor within it and prevent ignition of the gas or vapor surrounding the machine.

Dust-ignition-proof: Designed and constructed to exclude ignitible amounts of dust to prevent ignition or explosion of ambient atmosphere around machine.

UL in its "Hazardous Equipment List," which indicates the NEC Class and Group for which each listed motor is designed. In general, Class I locations are those where flammable gases or vapors may be present; Class II locations are those where combustible dust may be present. Class I is subdivided into Groups A, B, C and D, according to the types of vapors; Class II is subdivided into Groups E, F and G, defining the types of dust (see box).

To date, UL lists no motors for Groups A and B; hence where such conditions are encountered, motors must be located outside the hazardous area. Motors suitable for Class I locations are designated as explosion-proof; those for Class II locations as dust-ignition-proof. All are totally enclosed and available either non-ventilated or fancooled.

A third condition, designated as Class III, covers the presence of ignitible fibers or flyings, such as textile mill products and woodworking plants. UL lists no Class III motors as such; however, totally enclosed non-ventilated motors and the so-called lint-free or self-cleaning textile squirrel-cage motors are

commonly used. The latter may be acceptable to the local inspecting authority if only moderate amounts of flyings are likely to accumulate on or near the motor, which must be readily accessible for routine cleaning and maintenance.

Each of these three classes is also divided into two divisions. Division 1 applies to areas where the specific contaminant (vapor, dust, etc.), exists continuously, intermittently or periodically; Division 2 applies to areas where the contaminant is used or handled but will be confined within containers or closed systems except in case of an accident or breakdown.

The code relaxes the requirements for Division 2 areas somewhat. In Class I and Class II Division 2 locations, for example, open or nonexplosion-proof enclosed motors may be used if they have no brushes, switching mechanisms or integral resistance devices.

Motors having such devices may be permitted, provided that they are enclosed in tight metal housings approved for the location.

In locations where dust or flying material will collect on or in motors to such an extent as to interfere with their ventilation or cooling, enclosed motors which will not overheat under the prevailing conditions must be used. It may be necessary to require the use of enclosed pipe-ventilated motors or locating the motor in a separate dust-tight room, properly ventilated from a source of clean air (NEC Sec. 430-16).

The reference to ventilation is clarified in Sec. 502-9 and 502-9 (B): "Vent pipes for rotating electrical machinery shall be of metal not lighter than No. 24 USS gauge, or of equally substantial noncombustible material. It shall lead directly to a source of clean air outside of buildings, be screened at the outer ends to prevent the entrance of small animals or birds, and be protected against physical damage and against rusting or other corrosive influence.

"Vent pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of dust into the ventilated equipment or enclosure, and to prevent the escape of sparks, flame or burning material which might ignite dust accumulations or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints may be

used, and tight-fitting slip joints may be used where some flexibility is necessary, as at connections to motors."

Typical conditions where these requirements may apply include processing machinery or enclosed conveyors where dust may escape only under abnormal conditions, or storage areas where handling of bags or sacks may result in small quantities of dust in the air.

Liquid or condensed vapor may present a problem in Class I locations. Where such is the case, joints and conduit systems must be arranged to minimize entrance of liquid. Periodic draining may be necessary, which necessitates the inclusion of means for draining in the original design of the motor (NEC Sec. 501-5-C-6).

#### Controllers

Selection of the correct controller will always demand a detailed

knowledge and consideration of the motor to be controlled, the functions to be performed, the equipment to be driven, the location, and the distribution system. The controller must then be installed to insure convenient and efficient operation in accordance with applicable safety codes.

The major functions of a motor controller are to start and stop the motor and to protect it against overloads. Additional functions may be built into or performed by the controller, such as fulfilling circuit disconnect requirements; controlling motor starting voltage, speed, acceleration, and direction of rotation; providing means of interlocking related equipment; and affording protection against undervoltage, phase-failure, and phase reversal.

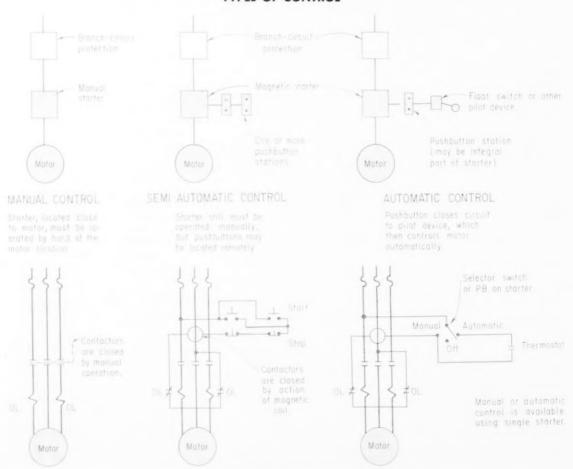
Small motors up to  $\frac{1}{8}$  hp and portable motors up to  $\frac{1}{8}$  hp may use simple appliance switches for control. Larger motors, however, must be furnished with some type of

overload protection. The simplest motor starter differs from a switch in that it incorporates the overload protector. Starting and stopping may be accomplished by the starter (or controller) either manually by the operator or automatically by some type of "pilot device" such as a float switch, limit switch, thermostat, or time switch.

Small, compact manual starters for fractional-horsepower motors, incorporating an on-off toggle switch, fit into standard switch boxes. Larger ratings use startstop pushbuttons mounted in the enclosure cover. Both may be adapted for automatic operation in conjunction with a pilot device capable of carrying and interrupting the full motor current. Overload protection provided usually includes a "trip-free" feature which makes it impossible for the operator to run the motor by holding in the start button once the overload device has opened the circuit.

Where automatic control or re-

#### TYPES OF CONTROL



#### TYPE DESCRIPTION APPLICATION AND CHARACTERISTICS

(NEMA Designations)

General purpose Indoors and where atmospheric conditions are normal.

2 Drip-tight Shields protect against dripping.
3 Weather-resistant For use where exposed to rain or sleet; on docks, canal locks, and in subways and tunnels.

4 Water-tight For use outdoors; where exposed to splashing or dripping water.

Dust-tight Prevents entry of dusts in non-hazardous areas such as cement mills, steel mills, and coke plants.

5 Submersible For use where unit may be submerged in water, as in mines, quarries, and manholes.

Hazardous locations For Class I, Group D locations containing hazardous gases.

Hazardous locations Similar to Type 7, but contacts are immersed in oil; for use where gases are corrosive.

9 Hazardous, dust-tight
For use in Class II locations such as flour mills and grain elevators.

10 Bureau of Mines For use in coal mines.

Corrosion-proof

For use where exposed to corrosive acid or fumes, as in chemical plants or plating rooms.

For use in automotive and other industrial plants; protects against dirt and oil, lint, flyings, and fibers. Used extensively as improved substitute for Type 1.

#### **CONTROLLER SIZES**

(NEMA Designations)

Motor Voltage	Motor Maximum HP (3-Phase)	Starter Size
	11/2	0
	3	1
110	71/2	2
	15	3
	25	4
208-550	3	0
	5	1
	15	2
	30	3
208-220	50	4
	100	5
	200	6
	300	7
	71/2	1
	25	2
	50	3
440-550	100	4
	200	5
	400	6
	600	7

mote operation of the motor from one or more points is desired, the magnetic starter is used. The contactors of the starter, instead of being opened or closed manually. are operated by energizing or deenergizing an electromagnet within the enclosure. The magnet coil is in series with the pilot device or pushbutton station, constituting the control circuit. Over-voltage contacts as well as contacts of other protective devices are also wired in series with the coil. Opening of any one of the contacts for any reason will de-energize the coil and open the contactors, stopping the motor. The control circuit may derive its power from the motor branch circuit and may operate at the same voltage as the motor or at a reduced voltage.

11

12

Industrial

#### **Overload Protection**

Motor overload protection in most cases is provided by thermal overcurrent relays usually incorporated within the controller. Branch circuit fuses, designed to protect the circuit conductors and the equipment against the effects of short circuits, are normally incapable of supplying protection against sustained overloads, which involve a gradual increase of winding temperature. The period of time over which the motor is able to sustain higher-than-rated temperatures varies inversely as the current through the windings. For the majority of motors in use, therefore, the overload protective devices are designed to be sensitive to current changes. Their coils or heaters are wired in series with the motor supply conductors. If the motor begins to draw excessive current from the line, the heater will cause line contactors to open, breaking the current to the motor.

Most overload relays today are designed for a specific current range, and the appropriate relay for the motor to be protected (NEC Sec. 430-42, 430-34) must be specified when ordering the controller. Starter manufacturers publish tables designed to provide full information for selecting relays for its line of starters.

Air- or oil-dashpot-type relays,

introducing a time delay, may be adjusted for any trip current within their range. The time delay may be adjusted so that the relay will not operate on starting current, but will open on any overload exceeding its rating. Such relays may be ordered as part of the controller.

Consideration must be given to the relative ambient temperatures of the controller and the motor. If the controller operates in a higher ambient than the motor, a larger size relay may be appropriate. Conversely, smaller-size relays should be selected where the motor ambient is higher than that of the controller.

Used extensively in hermetic motors of air-conditioning and refrigeration compressors is the inherent heat-sensitive protector, which is built into the motor. Recent development of the 3-phase protector has extended its use to such applications as fans and blowers, machine tools, and production machinery. With no need for external protectors, a manual switch or magnetic contactor may be used as the motor controller in place of

the conventional starter. Such a switch may also serve as the circuit disconnect (NEC Sec. 430-111). Contacts are opened by action of a bimetallic disc when a predetermined temperature is reached. Resetting may be accomplished either manually or automatically. Where unexpected starting of the motor may cause a hazard, manual reset should be used.

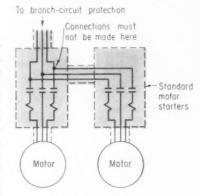
#### Other Starter Functions

Disconnecting: Where it is practical to locate the motor disconnect and starter at the same spot, a combination starter may be used. Such a device incorporates a starter and a disconnecting means in the same enclosure, resulting in less required mounting space and reduced wiring and labor costs. The installation improves the safety factor, since the cover cannot usually be opened with the disconnect closed. The disconnect furnished may be either a fusible or non-fused switch or a circuit breaker.

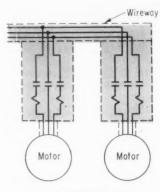
Reduced-voltage starting: Although all motors may be started by applying full voltage to the motor, the sudden inrush of starting current may be objectionable in the case of large motors due to its effect on the distribution system. Also, applying full-voltage starting torque to the driven load may have a detrimental effect on the load and its component gears,

#### WIRING SPACE IN ENCLOSURES

Enclosures for controllers and disconnecting means for motors must not be used as junction boxes, troffers, as raceways for conductors feeding through or tapping off to other apparatus unless designs are employed which provide adequate space for this purpose (NEC Sec. 430-10). Since no such special controllers are listed by Underwriters' Laboratories, they would have to be custom built and submitted for approval to the local inspection authority. The extra expense and uncertainty of acceptance usually dictaics wiring with conventional equipment such as wireways or independent conduit runs.



NOT PERMITTED



ACCEPTABLE

couplings, pulleys, or fan blades. Where this is the case, a reduced-voltage starter may be used, which introduces the initial current to the motor through resistors, reactors, or autotransformers. In selecting a reduced-voltage starter, it is important to determine whether resulting starting torque will be sufficient for the driven load, since starting

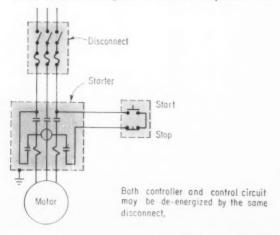
torque decreases as the square of the voltage.

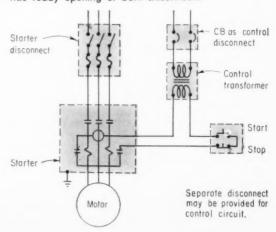
The manual reduced-voltage starter, or "compensator," is usually furnished with an operating handle which in the start position connects movable contacts to the starting circuit. When the motor has gained sufficient speed, the handle is thrown to the run posi-

#### CONTROL CIRCUIT DISCONNECT

Control circuits operating contactor coils, etc., within controllers present a shock hazard if they are allowed to remain energized when the controller is in the "off" position. Therefore the control circuit either must be designed in such a way that it is

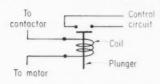
disconnected from the source of supply by the controller disconnecting means or must be equipped with a separate disconnect immediately adjacent to the controller disconnect (NEC Sec. 430-74) to provide ready opening of both disconnects.

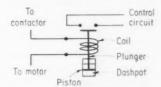




#### TYPES OF OVERLOAD PROTECTION

#### CURRENT-SENSITIVE RELAYS





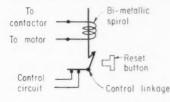
#### MAGNETIC TYPE

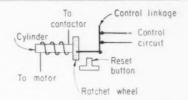
Excessive current through coil draws plunger up, opening control circuit, which opens contactor and stops motor.

#### DASHPOT TYPE

Similar to standard magnetic type in operation. Air or oil in dashpot restricts rate of travel of plunger, introducing time delay.

#### HEAT-SENSITIVE RELAYS





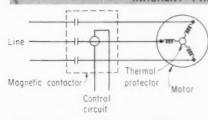
#### BI-METAL TYPE

Heat expands spiral, causing connected plunger to rise, releasing control linkage and breaking control circuit. Reset button must be pressed to restore linkage.

#### FUSIBLE-ALLOY TYPE

Alloy strips normally keep cylinder from turning. If heat melts alloy, spring turns cylinder and rachet wheel, releasing control linkage and opening control circuit. Relay may be reset when alloy hardens.

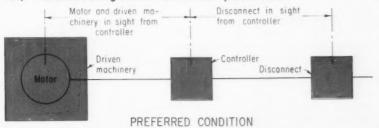
#### INHERENT PROTECTOR



Incorporating protector within motor housing permits it to sense both excessive motor current and ambient heat. A single 3-phase protector will respond to unbalanced currents on any of the three phases.

#### LOCATING CONTROLLER AND DISCONNECT

If motor and driven machinery are not in sight from controller, the controller or its disconnecting means must be capable of being locked in the open position, or a manual switch must be placed within sight from the motor which is capable of preventing the motor from starting (NEC Sec. 430-86). The disconnecting means must be in sight from the controller or be arranged to be locked in the open position (NEC Sec. 430-102). The disconnecting means shall be readily accessible.



"In sight from" means "visible and not more than 50 ft distant." (NEC Sec. 430-4)

tion, which connects full voltage to the motor. Compensators incorporate overload protection.

Part-winding squirrel-cage motors are often used where reduced voltage and starting torque is required, such as for centrifugal fans, blowers, and air conditioning systems. Part-winding starters are used for such motors, consisting of two starters, each controlling one of the two motor windings.

For wound rotor (slip ring) motors, a secondary-resistor-type reduced voltage starter is used, equipped with resistors which are connected in series with the motor windings during starting. Complete specifications of the motor to be controlled must be available for proper selection of the starter.

Reversing: A starter designed to provide reversal of rotation is called a reversing starter. It is essentially two separate starter mechanisms mounted in a single enclosure and incorporating a mechanical interlock to prevent both starters from closing at the same time.

An alternative to using a reversing starter is to provide a reversing switch, such as a drum switch, in conjunction with a standard starter. The starter provides overload protection, not available as part of the drum switch. A typical load application is a machine such as a lathe; the starter may be mounted on the wall and the drum switch on the lathe within easy reach of the operator.

Low-voltage protection: Where power failures are common, it is important to eliminate the possibility of unexpected restarting of a motor when power is restored. This could occur where a magnetic starter is used with a pilot device for automatic operation. Protection against this occurrence may be provided in starters by the inclusion of a holding circuit consisting of a set of contacts wired in parallel with the start button and thus in series with the contactor coil. Normally closed while the motor is running. the contacts open in case of power failure. The start button must be pressed to close the contacts again. Phase failure and reversal protection: An accidental opening of one phase of the line supplying a motor may under certain conditions damage the winding without tripping overload units. On large motors, this possibility is eliminated by providing voltage relays across each phase.



# Conductors

LECTRICAL conductors are the "nerve network" of an electrical system, transmitting current from service equipment or power source through distribution centers to individual electrical loads. As such, they provide the vital links that tie together the various electrical equipment components into a smoothly operating, trouble-free system. The National Electrical Code lists no less than 26 basic types of insulated conductors for application within specified operating conditions and temperature limitations. Design engineers select and specify conductor sizes, types and insulations to match load requirements and anticipated operating conditions of the electrical system under consideration. Whether or not the end result is achieved depends, to a considerable extent, on the manner in which the plans and specifications have been translated into a closely integrated system of physical components.

Much of this responsibility is in the laps of the installing contractor, his field engineers and installation crews. Their knowledge, skills, and the care they exercise in the installation, supporting, splicing, and termination of wires and cables has a definite bearing on the ultimate efficient, trouble-free operation of the system as designed.

While insulated conductors are of rugged design and construction, it is only logical that ordinary care be used when handling and installing them. This means giving adequate consideration to the following:

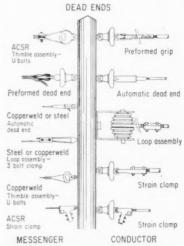
Raceway Fill—Check with NEC limitations and be sure raceway permits cable pulling with ease.

Raceway Obstructions — Clean and swab raceways before pulling cables.

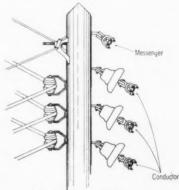
Minimum Bending Radii — Cables can be damaged by bending too sharply. The NEC limits the minimum bending radius of Types MI, AC and NM cables to five times the diameter of the cable. An accompanying table gives the minimum bending radii for rubber insulated cables. It is good practice to use larger radii when installation conditions permit.

Maximum Pulling Tensions — Stay within prescribed limits (see accompanying table) to prevent cable sheath damage and/or conductor elongation. Cables weakened by excessive pulling tension during installation can lead to possible future failure that will be expensive to both owner and contractor.

Pulling Techniques — Cable installation techniques have been evolved for practically every type and assembly of electrical conductor. Suggested methods are offered by cable manufacturers. Installation crews may adapt or tailor these to specific installation requirements,



VARIETY of dead-end techniques for messengers and conductors in overhead line work



ANGLE AND TURN SUPPORTS

**ONE METHOD** of supporting conductors in vertical plane at angle and turn points along overhead line

or they may develop their own. All have a common goal—quick, safe installation of cables without damage to conductor or insulation. To this end, contractors use a variety of approved cable lubricants, rollers, pulley assemblies and other friction-reducing devices suitable to the installation problem at hand. A number of these are illustrated in the succeeding pages.

Adequate Supports—These must be provided, both horizontally and vertically, to properly distribute cable weight and (for open wiring) to maintain recommended distances between phase conductors, surrounding structures and ground level (elevation). Maximum spacing of supports and minimum clearances for conductors are noted in the NEC. Where indicated, physical protection also must be provided.

Splices and Terminations - Unless properly made, splices and terminations can become the weakest points of an otherwise well-installed conductor system. It is poor practice to risk compromise with tested and proved techniques recommended by cable and insulation manufacturers. To assure mechanically and electrically secure splices and terminations, experienced mechanics should follow the indicated step-by-step procedures. While general techniques may be similar, specifics for each splice and termination category vary with the rated voltage of the conductor, type

#### CALCULATION OF PULLING TENSION IN DUCTS

#### For Straight Duct Section

 $T = L \times w \times f$ 

T = Total pulling tension

L = Length of duct run, feet

w = Weight of cable, pounds per foot

f = Coefficient of friction = 0.5 for well constructed ducts.

#### For Duct Runs with Curved Section

 $T = T_2 + T_1 e^{fa}$ 

 $T_2$  = Tension for straight section at pulling end

 $T_1 = \text{Tension for straight section at feeding end}$ 

e = Naperian logarithm base = 2.718

f = Coefficient of friction = 0.5

a = Angle of bend in radians (1 radian-57.3 degrees)

#### **MAXIMUM PULLING TENSIONS**

For Installing Electrical Wires and Cables

With Pulling Eye Attached to Conductor

Maximum Tension in pounds shall not exceed 0,008 x CM area.

 $T_m = 0.008 \times n \times CM$ 

 $T_m = Maximum tension in pounds$ 

n = Number of conductors in cable

CM = Circular mill area of each conductor

With Basket Grip Around Cable Sheath

Lead Covered Cables—Maximum strain shall not exceed 1500 lbs./ sq. in. of lead sheath area

 $T_m = 4712 + (D-t)$ 

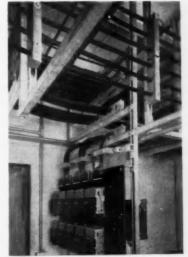
t = Lead sheath thickness, inches

D = Outside diameter of cable, inches

Non-leaded Cables—Maximum strain shall not exceed 1000 pounds, or T<sub>m</sub> limitation for pulling-eye technique. Maximum Strain at a Bend shall not exceed 100 times the radius of curvature of the duct, in feet, or T<sub>m</sub> as determined above.

# INSTALLATION PRECAUTIONS THAT INCREASE WIRE AND CABLE LIFE AND EFFICIENCY

- Store conductors and cables in a cool, uniform temperature area before installation.
- Keep cable riser conduits on north or shaded side of poles away from sun.
- Ventilate pole riser conduits to create air circulation around cables.
   Fittings are available for this.
- Protect cables with abrasion-resistant wrappings at duct mouths and extend arc-proofing wrapping back into end of duct.
- Ventilate cable tunnels with grilles or blowers to prevent accumulation of hot air.
- Place baffles between cables (and ducts) and steam or hot pipes to deflect hot air away from cables.
- Install cables below bridge or viaduct structures for protection from sun and weather.
- Place (pack) soft fill around direct-burial cables in trenches to improve heat dissipation.
- Use approved cable lubricants when pulling conductors in raceways and ducts. Avoid sharp feed-in and pulling angles. Prevent cross-overs.
- Make all cable connections, splices and terminations in approved manner, according to manufacturers' recommendations, to assure secure joint with adequate insulation and seal against ingress of moisture.



CHANNEL FRAMING supports tiers of power and control cables. Split-blocks holding cables slide along channel before tightening for cable alignment.

#### NEC RULES FOR CONDUCTOR INSTALLATION

#### Article 230—Service Entrance

Open Conductor Supports—Outdoor with 6-in. separation, maximum spacing is 9 ft; with 12-in. separation, 15 ft; for services 300 volts or less, separation 3 in., spacing 4½ ft. Minimum distance from structure surface to conductor, 2 in. Indoor, with minimum 2½-in. separation, 4½-ft spacing; 1-in. distance from surface wired over (230-47-48).

Service Cable—Type not approved for mounting in contact with building must be supported at least 2 in. from surface at maximum 15-ft intervals; contact-mounting type, supported at 4½-ft intervals (230-50).

Point of Attachment—Service Drops. Service drops must be attached to building at least 10 ft above finished grade. Minimum clearance of drops above sidewalks 10 ft; above driveways and roads, 18 ft (230-26).

Underground Service conductors when carried up a pole shall have mechanical protection at pole at least 8 ft above the ground (230-32).

#### Article 300-Wiring Methods

Conductors of different systems (light and power, 600 volts or less, ac or dc or both) may occupy same enclosure if all conductors are insulated for maximum voltage of any conductor in enclosure (see 300-3 for details and exceptions).

Through Studs, Etc.—Where permissible, armored, Types NM or MI cable may be laid in notches in studding or joists if notch is covered with  $\frac{1}{16}$  in. thick steel plate as protection against driven nails (300-8).

Conductor Continuity—Conductors must be continuous between outlets, devices, etc., with no splice or tap within a raceway itself (300-13).

Wiring Transition—A suitable, approved box or terminal fitting must be used where conductors change from raceway, type NM, AC or MI cable to open wiring or concealed knob-and-tube-work (300-16).

#### Article 310-Conductors for General Wiring

Conductor application and construction shall conform to regulations and Tables of Section 310-2 of NEC. Conductors shall be approved for temperature and installation conditions encountered (310-3 to 310-8).

Stranded Conductors—Conductors No. 6 and larger, when installed in raceways, shall be stranded except when used as bus or in MI cable (310-9).

Conductors in Multiple—Conductors sizes 1/0 and larger may be run in multiple if: they are of same length, same circular-mil area, have same insulation, and are terminated at both ends in manner to insure equal division of total current among conductors involved (310-10).

#### Article 320-Open Wiring on Insulators

Supports—Single conductors shall be rigidly supported at maximum 4½-ft intervals over flat surfaces on non-combustible, non-absorptive material; and within 6 in. of a tap. When installed across undisturbed open spaces, conductors No, 8 or larger may be supported at 15-ft intervals if insulating separators (2½-in. spacing) are installed every 4½ ft. In mill construction, open feeders No. 8 or larger may be separated 6 in. and supported from each timber (320-5).

Conductor Separation—Up to 300 volts, 2½ in. between conductors and at least ½ in. from surface wired over (1 in. in damp or wet locations). From 301 to 600 volts, 4 in. between conductors and at least 1 in. above surface wired over (320-6).

Conductor Protection—Open conductors shall be separated at least 2 in. from metal conduit or other con-

ducting material; shall have maintained air space from water piping; shall be protected where crossing joists and studs and exposed to physical damage (within 7 ft from floor) by guard strips, running boards or tubing; shall have drip loops where entering or leaving damp, wet or corrosive areas (320-10 to 320-14).

#### Article 324—Concealed Knob-and-Tube Work

Supports—Single conductors shall be supported at maximum 4½-ft intervals and within 6 in. of a tap; may be fished in dry locations if conductors are separately enclosed in non-metallic flexible tubing of continuous length between supports or boxes (324-5).

Separation and Protection—Separation between conductors shall be at least 3 in.; distance above surface wired over, 1 in. minimum. Where separation cannot be maintained, each conductor must be encased in continuous length of flexible tubing. Separation and protection from other objects follows Article 320 (324-6 to 324-9).

#### Article 330-Type MI Cable

Supports—MI cable shall be securely supported by approved staples, straps, hangers or fittings at maximum 6-ft intervals, except where fished; shall have at least 1/4 in. air space between cable and supporting surface in wet locations (330-4, 330-6).

Bends—Radius of curve of inner edge of any bend shall be not less than five times cable diameter (330-7).

Terminations—An approved seal shall be provided to MI cable terminations immediately after stripping to prevent insulation absorption of moisture; conductor extensions shall be properly insulated. Where cable is connected to boxes, fittings approved for conditions of service shall be used (330-8, 330-9).

## Article 334—Armored Cable (Types AC, ACT, ACV,

Supports—Except where fished, armored cable shall be secured by approved staples, straps or fittings at maximum 4½-ft intervals and within 12 in. of every box or fitting. Cable in accessible attics or roof spaces where run across top of floor joists or within 7 ft of floor shall be protected by substantial guard strips (334-5 to 334-8).

Conductor Protection—At terminal points of armor, a fitting shall be provided to protect wires from abrasion and an approved insulating bushing shall be provided between conductors and armor (334-9).

Bends—Radius of the curve of inner edge of any bend shall not be less than five times the cable diameter.

## Article 336—Non-Metallic Sheathed Cable (Types NM, NMC)

Supports—Except where fished, cable shall be secured in place by approved staples, straps, etc., at maximum  $4\frac{1}{2}$  ft. intervals and within 12 in. from cabinet or box. In unfinished basements NM assemblies larger than two No. 6 or three No. 8 conductors may be secured to lower edges of joists; smaller assemblies may be run through holes bored in joists or on running boards (336-5 to 336-9).

Bends—No bend shall have radius less than five times cable diameter (336-10).

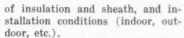
#### Article 339-Underground Feeder Cable (Type UF)

Installation—All single-conductor cables of a circuit shall be run together in same trench or raceway. When direct burial is used, authority enforcing the code may require, when considered necessary, supplementary mechanical protection over or around cable (339-3).

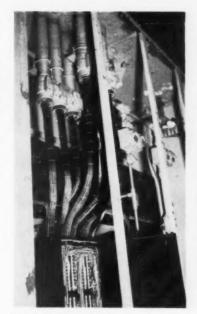
- A Soft bed of sand or screened fill.
- B Blanket of sand or screened fill 6 in. to 8 in. above top of cable.
- C Cable "snaked" slightly in trench for slack when earth settles. Keep single-conductor cables uniformly apart about 6 in. in trench. Avoid cable cross-overs. Keep cable below frost line.
- D Add protective slab (creosoted plank, etc.) on sand fill in areas where future digging might occur. Enclose cable in pipe or conduit under highways or rail tracks.
- E Normal back-fill.



**RECOMMENDED METHOD** of installing direct-burial cable in trench to assure adequate protection. For high-voltage cables, trench should have minimum depth of 36 in.



Progressive developments in the methods of terminating cables have simplified this phase of electrical installation and substantially reduced the possibility of cable failure due to human error or poor workmanship. A wide range of fittings and devices are available to protect and seal cables at equipment



**CONDUCTOR GROUPS** emerge from conduit sealing fittings; are carefully tied and trained into terminal box at meter and control panel.

enclosure terminations and at points of transition from raceway to open air. A series of termination and splicing fittings for interlocked armor cable has extended the application of this conductor assembly as a distribution medium. Bolted, pressure type and welded type connectors and lugs assure large-area, positive electrical contact, cut cable termination time, and are generally preferred to the time-



**IDENTIFICATION** of circuit conductors with tags, adhesive labels, etc., simplifies original connection to proper terminals and adds speed and ease to future checkout should trouble occur.

consuming soldering techniques. Continued research and development in the aluminum conductor and connection fields have reduced termination and contact problems to the point where acceptance and use of aluminum conductors, with their light-weight, low-installation-cost advantage, have shown rapid gains.

Equal in importance to the mechanical and electrical strength of



**CONDUIT STUBUP** gives mechanical protection to direct-burial MI cable circuit to outdoor pump. Note separate grounding conductor going down concrete base from motor frame.



**REMOVABLE RUNGS** of insulating material support dual tier of feeder cables in large, roomy pullbox under riser shaft.



CUSTOM-BUILT TROUGH carries 40 500 MCM feeder conductors in double offset across hotel corridor; protects cables by providing plenty of space for gentle, sweep bends.

#### CALCULATION OF MESSENGER TENSION

... for Self-Supporting Aerial Cables

$$T = \frac{WS^2}{8d}$$

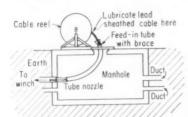
T = horizontal tension in messenger, in pounds

W = weight of cable and messenger, lbs per ft

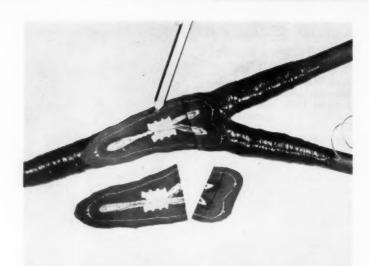
S = length of ruling span, in feet. (Ruling span is the average span plus 2/3 the difference between average and maximum spans)

d = the sag, in feet

Check manufacturers' recommendations of tension values for size and type of messenger used in aerial cable assembly.



**FEED-IN TUBE** protects sheath of leadcovered cable pulled in underground duct; prevents bending cable sharper than reel diameter.



**EPOXY RESIN SPLICE** cut-away shows complete saturation and penetration of set-up resin around connector and cable strands.

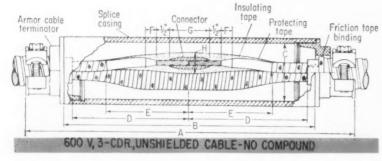
## CONDUCTOR SUPPORTS IN VERTICAL RACEWAYS

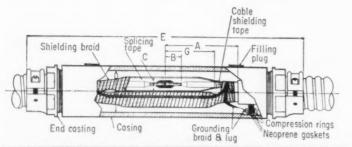
Conductor Size Maximum Spacing
Between Supports

No. 18 to No. 1/0 100 ft No. 2/0 to No. 4/0 80 ft 250MCM to 350MCM 60 ft 350MCM to 500MCM 50 ft 500MCM to 750MCM 40 ft Over 750MCM 35 ft

Source: 1959 NEC Article 300-19

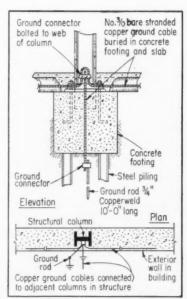
a conductor splice or termination is the insulation of the exposed connection. Insulation materials must be field-applied according to prescribed methods to provide a built-up protective covering that matches the dielectric and moisture-resistant characteristics of the original conductor insulation and cable sheath. To assure proper, long-life, trouble-free splices and connections, manufacturers of cables, termination fittings and devices, and in-





UP TO 5-KV, 3-CDR. SHIELDED CABLE-COMPOUND PLUGS

**SPLICING FITTINGS** for interlocked armor cables permit in-line splices on racks without cumbersome splice cabinets or boxes. Available kits include casing and all splice materials.



**ONE METHOD** of grounding building structural members to ground cable system.

sulating materials provide detailed step-by-step instructions and drawings for contractors' field use.

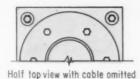
Field-insulation of cable splices no longer is an excessive time-consuming operation. The variety of improved tapes, electrical insulating putty, and protective cable wraps drastically cut overall installation time. The use of pre-formed or field-formed molds with gravityflow or pressure-injected epoxy insulating resin provide splice encapsulation in short order. Availability of unit-package splicing kits gives added assurance that the splices will be made properly. Each kit contains all items for a finished splice, from tinned sleeves and solder to proper materials for insulation build-up. Kit materials are tailored to a specific conductor size, insulation, voltage, cable outer sheath construction and type of splice or termination. Manufacturers' catalogs list the full range of kits for easy reference and selection. Application of these splicing "packages" simplifies estimating and ordering and assures the contractor and his mechanics that the right amount of proper materials will be on the job for each splice.

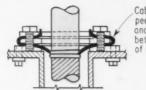
#### Busways

Functionally, factory pre-assembled busways are in the same category as wires and cables. So are field-assembled bus-bar systems. Basically, all are electrical conductors connecting the equipment components of an overall system design.

Busways, with their recognized advantage of flexibility and reusability, have become an established method of transmitting 600-volt (or less) power to: distribution points (feeder duct); lines of individual stationary equipment (plug-in duct); rows of lighting fixtures and/or groups of mobile devices (trolley duct). The inherent design of busway sections (bus bars and protective enclosure) reduces installation problems to the level of relatively simple supporting methods. In one operation, conductor and raceway are put in place.

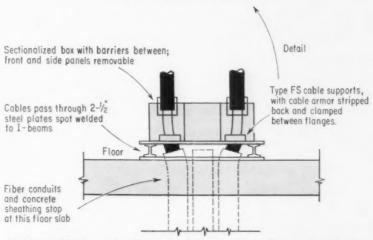
In-line connection of conductors involves tightening one or more bolts at section joints. Branch circuit taps are made with plug-in devices or mobile inserts (for trolley duct). Latest development in several bus duct systems is the design of a "one-bolt" compression joint





Cables armor peeled back and clamped between flanges of support

TYPE FS CABLE SUPPORTS



**ARMOR CLAMPS** provide effective single-point support of armored cable risers. Separate strands of cable armor are snubbed between flanges of support fitting at top of run. Partitioned enclosure protects unarmored sections of cable.

## MINIMUM BENDING RADII FOR VARIOUS TYPES OF INSULATED CABLE

Single and Multi-Conductor-Rubber-Insulated Cables

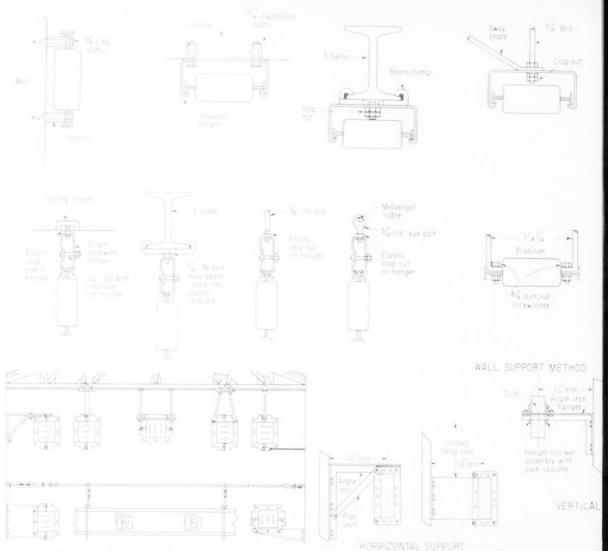
Cond. Size MCM	Insulation Thickness 64th, In.	Non-Shielded	Armored*
	0–8	3 x O.D.	12 times
	9-12	4 x O.D.	outside
0-499	13-20	5 x O.D.	diameter
	Over 20	6 x O.D.	
	0-8	4 x O.D.	12 times
500 and Over	9-12	5 x O.D.	outside
	Over 12	6 x O.D.	diameter

\*All interlocked steel tape cables take minimum bending radius of 8 times OD because of their high flexibility.

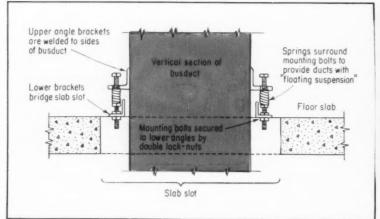
for busway conductors which permits tightening and checking pressure on the interleaved bars from outside the duct enclosure with the bus dead or hot. New busway designs incorporate continuously insulated conductors, except at section joints and plug-in outlets.

The development of economical methods of silver-coating aluminum bus has substantially increased its use in busway design and construction. In fact, some forecasts indicate that within the next few years about two-thirds of all busway made will have aluminum conductors. With this material and new designs, overall weight of busway sections has been reduced to the point where the number of required supports can be cut almost in half.

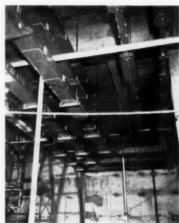
Concurrent with new busway designs has been a simplification of supporting devices. In addition to the conventional clamp-hangers is



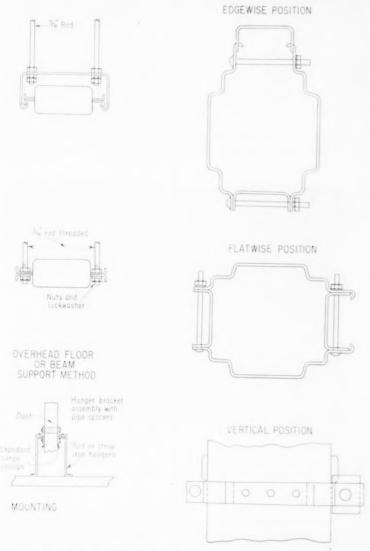
TYPICAL SUPPORTING METHODS for a variety of busways to meet structural and accessibility conditions. Included are the



**SHOCK-ABSORBING SUPPORTS** for busway risers in buildings designed to withstand earth tremors. Three heavy-duty coil springs on each side of riser form cushion between duct and floor brackets.



**TRAPEZE HANGERS** from ceiling inserts suspend triple tiers of busway from basement distribution boards to riser shafts.



latest snap-on and clamp hangers available for specific ducts.

## NEC INSTALLATION RULES FOR BUSWAYS-ARTICLE 364

#### **Busways:**

- 1. May be used for service entrance conductors.
- May be installed only for exposed work; shall not be installed where subject to severe physical damage or corrosive vapors; in hoistways; in any hazardous location; nor outdoors or in wet or damp locations unless specially approved.
- Shall be securely supported at 5-ft maximum intervals unless approved for greater distances when maximum shall be 10 ft.
- May extend transversely through dry walls if bus is in unbroken lengths at wall; may extend vertically through dry floors when totally enclosed at floor and at least 6 ft above floor.
- 5. Shall be closed at dead-ends.
- Shall have branches made of busways, metal conduit, EMT, surface metal raceway, armored cable, or cord assemblies.
- 7. May be reduced in size without overcurrent protection if extension is 50 ft or less in length, not in contact with combustible material, and has current rating at least equal to one-third that of overcurrent device next back on the line.
- 8. In general, length of plug-in type branch circuit busway run, in feet, shall not exceed three times ampere rating of circuit.

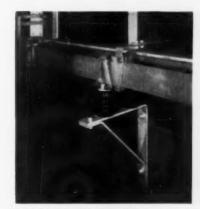
a new line of snap-on units which hook on to the busway flange (or ventilating slots in some designs). If desired, conventional rod and bar supporting techniques can also be used. Methods of supporting the clamp and snap-on hangers will vary with the structural features of the building and the provisions (or limitations) established by the engineers in charge. Accompanying illustrations show a variety of techniques.

The installation refinements for trolley duct now permit contractors to install long rows of duct from a single work station, after supporting hangers have been mounted. More than one manufacturer of trolley duct offer supporting roller hangers through which platform-assembled duct sections can be moved into permanent position.

#### Field-Assembled Bus

Field-assembly of bus systems is usually a time-consuming operation with man-hours divided between measuring, cutting, bending, drilling or punching, plating contact areas and bolting bus sections within the limited confines of the system design.

Over the years, numerous techniques have been developed to slash construction time. Among them, to mention a few, were power bending and cutting, brush plating, welded joints. One newer method is the edge-bending of rectangular bus bar. By doing this, the project contractor drastically reduced the number of assembled connections in the system; maintained minimum spacing in multiple-bar runs.



INSULATED BUS CLAMPS mounted to simple wall bracket support open bus bar distribution system. Bolted clamps provide high-compression lap joints and tapoffs without piercing main bus section.

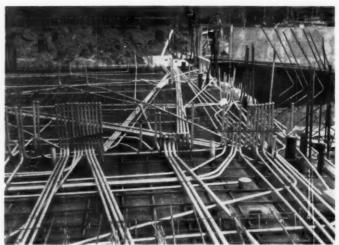


# Raceways

RIGID metal conduit is used extensively in all types of building construction since it provides maximum protection for conductors; permits conductors to be withdrawn or replaced; may be used indoors or out, in wet locations and dry, and installed under all atmospheric

conditions provided code-defined installation and protective measures are properly observed.

To meet various installation and atmospheric criteria, rigid conduit may be obtained either in steel (enameled or galvanized), aluminum, or copper alloys, choice of



**RESISTANCE TO MECHANICAL INJURY,** corrosion and vibration, plus easy bending, clean threads and good electrical characteristics were among the reasons influencing the selection of this rigid metal conduit installation. Tight connections plus capping of all open conduit ends kept the system free from water, moisture, dust and dirt as the work progressed.

## NEC Requirements RACEWAYS: General Requirements; Article 300

It may be stated in brief that metal raceways and fittings (unless corrosion-resistant) must be protected inside and outside (except at threaded joints) by coatings of corrosion-resistant materials such as zinc, cadmium or enamel. However, if ferrous raceways are protected solely by enamel, they can be used only indoors in occupancies not subject to corrosive influences. Raceways must also be continuous from outlet to outlet or from fitting to fitting, and must be securely fastened in place and mechanically secured to metal enclosures related to them.

If portions of an interior raceway system are exposed to widely differing temperatures, provision shall be made to prevent circulation of air from warmer to cooler sections through the raceway. And, wherever a change is made from surface metal raceway, conduit or EMT to open wiring, either a box or terminal fitting having a separate bushed hole for each conductor shall be used. An exception to this requirement permits bushings, in lieu of boxes or fittings, to be used at ends of conduits or EMT entering switchboards, control apparatus or similar enclosures.

Suitable boxes must be installed at all outlets or junction points of surface metal raceways, conduits or EMT, and interior metal raceways must be metallically joined together into a continuous electrical conductor. They must also be connected to all boxes, fittings and cabinets to provide effective electrical continuity. In addition (as prescribed in Article 250 of the NE Code), metal raceways and fittings must satisfy all conditions pertaining to grounding.

conduit and finishes depending upon local conditions (dry, wet, corrosive).

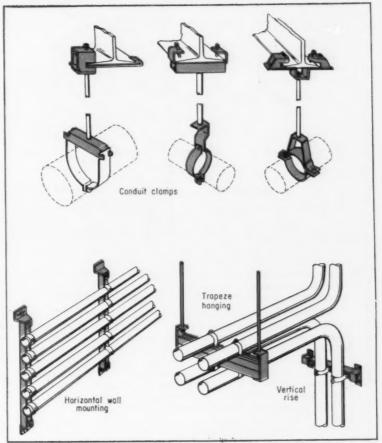
Conduit systems, of course, can be considered complete only when installed with a full complement of associated fittings, such as bushings (metallic or non-metallic, grounding or bonding or insulating), locknuts and jumpers, couplings and connectors (threaded or threadless), elbows, and wyes.

Selection of system components must likewise consider pull and junction boxes to provide (1) enough access points for wire feeding and pulling, (2) junction points for single or parallel conduit groups, (3) offset facilities to carry conduits around physical obstructions, and to (4) simplify installation of conductors where the number and degree of bends in any conduit run exceeds code limitations. Liberally dimensioned boxes are recommended to provide greater space for cable installation, support, splices and taps. And, although a wide selection of standard boxes is available, it is not uncommon (particularly on large installations) to design boxes and enclosures to satisfy specific local installation conditions.

Electrical metallic tubing, due to its lighter weight and threadlessconnection construction, is necessarily somewhat restricted if subjected to physical damage, corrosive atmospheres or other hazardous conditions. However, when codeapproved locations, installation methods and protective measures are observed, EMT provides an excellent raceway for electrical circuits carrying power at 600 volts or less, while a liberal selection of accessory fittings provides considerable latitude in design and installation.

## Conduit; Flexible and Liquid-Tight

Flexible metal conduit (a cross between EMT and armored cable minus the integral conductors) is a pull-in raceway, galvanized for the prevention of rust, designed for adequate grounding, and obtainable in various protected forms for use in damp locations or where subjected to oil, grease, dirt, chemicals, acid fumes or abrasion. Even where distribution is primarily via rigid raceways, flexible metal conduit may be incorporated for connecting machines subject to vibration or movement. Obtainable in long



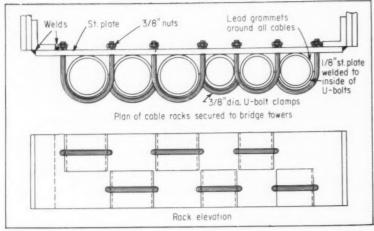
**RIGID CONDUIT** may be supported by numerous combinations of channel framing members, hangers, straps, brackets and clamps, a few of which are here illustrated.

## NEC Requirements RACEWAYS: Rigid Metal Conduit; Article 346

It may be generally stated that rigid metal conduit may be used under all atmospheric conditions and occupancies, indoors or outdoors, exposed or concealed, in wet or dry locations. However, use of dissimilar metals throughout a system should be avoided whenever practicable in order to minimize possibilities of galvanic action. Also, unless conduit is of corrosion-resistant material, it should not be placed in or beneath cinder fill, or where subject to permanent moisture conditions, except if protected on all sides by at least 2 in. of non-cinder concrete or located at least 18 in. under the fill. Moreover, in wet locations or where walls are frequently washed, the entire system must be installed and equipped to prevent water entering the conduit, and conduit must be mounted so that at least ½-in. of air space exists between conduit and supporting surfaces.

Uninterrupted runs of conduit between any combination of outlets and fittings must not contain more than 360 degrees of combined bends; all conduit ends must be reamed to eliminate rough edges; and wherever conduit enters a box or fitting, bushings shall be provided to protect conductors from abrasion (unless design of the box or fitting is such as to afford equivalent protection).

In installation, running threads must not be used at conduit-coupling connection points; threadless couplings and connectors must be made tight and, if buried in concrete or installed in wet locations, conduits must be enclosed either by concrete or fill of types that will prevent moisture from entering the distribution system.



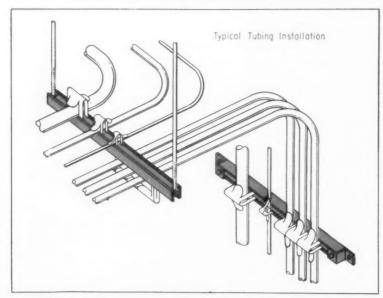
**STAGGERED CLAMPS** make it possible to install banks of conduit risers in minimumwidth space, as illustrated by this arrangement where grommeted U-bolts are positioned in two tiers and supported by steel backing plate.

## NEC Requirements RACEWAYS: Electrical Metallic Tubing; Article 348

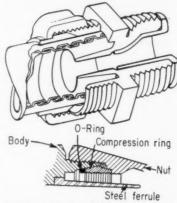
Like rigid metal conduit, EMT may be used in essentially the same manner for concealed as well as exposed work, although (due to its lighter construction) it may not be used where subject to mechanical injury; or if protected from corrosion solely by enamel; or in hazardous locations (with exceptions discussed in Article 500); or in cinder concrete or fill where subject to permanent moisture (except if it be protected and located as noted for rigid metal conduit).

If exposed to corrosive vapors or fumes, EMT and related fittings must be of corrosion-resistant material and, as noted above, dissimilar metals in the same system should be avoided wherever practicable.

Due to reduced thickness of tubing, connections of sections to each other or to boxes, fittings or cabinets are generally made by compression, indentation, set-screw or push-on devices, rather than by threaded connections, although approved threaded fittings (intentionally differing from standard pipe thread dimensions) may be used.



**SPRING CLAMPS** are also available for holding EMT firmly in place to the top, bottom or sides of lipped channels which in turn may be rod-suspended from overhead slabs secured to walls by means of Z-supports.



LIQUID TIGHT CONDUIT provides a practical, flexible raceway for locations subject to the presence of water, oil, chemicals or corrosive atmospheres. Special connectors, available in diameters up to 4 in., are designed to provide a positive oil seal, continuity of ground, and mechanical strength for the positive protection of the enclosed conductors. These cut-away and cross-section sketches show methods used by two different manufacturers to obtain positive compression seal.

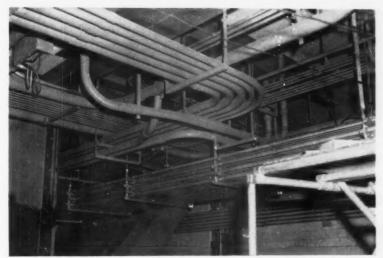
lengths; easily cut with a hacksaw; installed without fittings except at terminal points; and available in aluminum, brass or bronze with or without special fittings, synthetic or metal-braid coverings, flexible metal conduit is a useful member of the raceway family.

#### Surface Metal Raceways

Many advantages of wireways may be obtained on smaller scales by utilizing surface metal raceways which are obtainable in various shapes and sizes of cross sections, with several varieties of covers, straps and mounting clips, couplings, tees, elbows, grounding clamps, outlets, switch and receptacle boxes, end fittings, sockets and the like.

It is also possible to obtain reduction connections and twist-out fittings that permit several raceway sizes to be combined in a single installation, while a variety of adapters permit raceways to be connected to standard outlet boxes, switches and accessory fittings.

Simple and sturdy in construction, safe and tamper-resistant, neat in appearance and relatively inexpensive, surface metal raceways are easily installed and are hardly noticeable when painted to blend with background surfaces. For these several reasons, they provide practical modernization solutions



**USE OF ZINC** as protective coating for rigid steel conduit and EMT serves as barrier to seal out corrosive moisture. Zinc likewise saves base metal by sacrificing itself slowly in the cycle of galvanic action. This protective action, unique among corrosive protective measures, continues as long as sufficient zinc remains.

#### **NEC Requirements**

#### RACEWAYS: Conduit, flexible; Articles 350 and 351

Flexible metal conduit cannot be used in (1) hoistways; except between risers and such devices as limit switches, interlocks or operating buttons, (2) in storage-battery rooms, (3) in hazardous locations; except as permitted for flexible connections as defined in Section 5054-a-2, (4) in wet locations; unless conductors are lead-covered or other special types approved for those conditions are used, or (5) in locations where rubber-covered conductors are exposed to oil, gasoline or other material having a deteriorating effect on the rubber.

Liquid-tight flexible metal conduit is not intended as a generalpurpose raceway, and its use is restricted to connection of motors or portable equipment where flexibility of connections is essential. Neither is it recommended where subject to mechanical injury; where in contact with rapidly-moving parts; where its temperature would exceed 140 degrees F, or in any hazardous locations, except as permitted by Sections 5014-b, 5054 and 5073 in the NEC.

## RACEWAYS: Surface Metal; Article 352; Multi-Outlet Assemblies; Article 353

Surface metal raceways and multi-outlet assemblies may be installed only in dry locations where not subject to mechanical injury or corrosive vapors. This precludes their use in hoistways, storage battery rooms and hazardous areas. And, unless thickness of metal enclosures is at least 0.040 in., the potential between conductors cannot exceed 300 volts.

Unbroken lengths of *raceways* may be extended through dry walls, floors and partititions, and *multi-outlet assemblies* can also be so placed, provided no outlet falls within the wall and providing covers are provided on all adjacent, accessible sections.

In general, surface metal raceways and multi-outlet assemblies cannot be concealed, although *metal raceways* (when approved for the purpose) can be used for short under-plaster extensions; non-metallic *multi-outlet assemblies* may be recessed into baseboards, and *metallic* assemblies may be partially surrounded (back and sides) by the building finish.

When combination metal raceways are used for signal, plus lighting and power circuits, the different systems must be segregated in separate compartments identified by sharply contrasting colors on all interior finishes, while the same relative position of such compartments must be maintained throughout the premises.

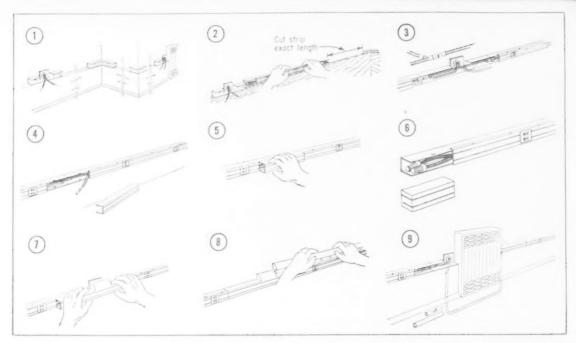
for installing extensions from previously installed outlets or for serving additional outlets and switches, as well as for providing easily accessible raceways in new construction.

Indicative of the range of possible surface-raceway applications: (1) where circuit requirements are minimum, compact surface metal raceways may be obtained having widths and depths of less than 1-in; (2) in industrial plants where raceways are required to serve numerous small motors, electric tools or heating units, wireways can be obtained with cross sections greater in area than 4 sq in.; (3) in locations such as offices, where desks are supplied with power, light or telephone service from remote outlets, a flat, bevelled-edge "pancake" type of raceway eliminates the tripping hazard; and (4) where highand low-potential wiring is to be installed along the same route, two rows of surface metal raceways can be mounted one above the other and in contact so that a common cover can be used to enclose both raceways, thereby simplifying wiring procedures and improving overall neatness of the installation.

The range of use possibilities is further indicated by the fact that components include (5) continuously covered raceways with covers either removable or permanently lipped to their bases; (6) raceways available either with electrical outlets fixed at standard intervals or placed at will to meet specific local requirements; and (7) assemblies which may be ordered either as prewired or unwired units.

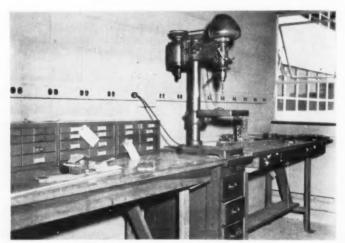
#### **Underfloor Raceways**

In the interest of simplicity and layout flexibility, design of modern commercial structures has been progressively streamlined to the point where basic construction now generally includes only outer shell, interior bearing columns, floor slabs, and such minimum partitioning as is necessary to define shafts, stairwells, service areas, and utility sections. While this "bare bones" approach offers maximum latitude for subdivision of floor area, it also emphasizes the importance of floor-contained electrical distribution systems that can serve numerous configurations of telephone, intercom, signal and power outlets, regardless of subsequent placement of walls or furniture. For this reason, critical attention should be



PLUG-IN STRIP, installed along baseboards in residential and commercial occupancies, illustrates another practical variety of a multi-outlet wiring system. Installation consists of (1) connecting the circuit feed, by means of a suitable connector, to a center-feed junction box; then (2) securing base sections to baseboard or wall by such means as clips, straps, nails or screws, as dictated by local construction details and molding design. Cover strips containing prewired receptacles are then pressed over base sections; and (3) circuit leads are connected to receptacle conductors by means of crimp connectors which may be insulated by tape or plastic sleeves designed for that purpose. Conductors in adjoining sections are (4) likewise connected and insulated (5) concealed by cover couplings; and,

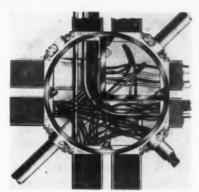
where lateral circuit wires terminate, (6) conductors are capped by wire nuts, after which end blanks are positioned to enclose the installation. Center-feed junctions may be concealed by cover sections containing quarter-round hoods corresponding to the contour of standard wood baseboard capping. If low-potential wiring such as telephone or communication circuitry is also to be considered, (8) hollow steel quarter-round trim, constituting a separate raceway, can be installed atop the plug-in strip in place of conventional wood, or may be installed at the floor line in place of toe molding, then used also for low-potential wiring. As indicated by sketch (9), doorways, fireplaces or heating units can easily be by-passed by means of additional fittings.



CLOSE SPACING of duplex receptacles in this shop permits variety of power tools and equipment to remain continuously connected, thereby eliminating the routine of repeatedly connecting and disconnecting tools as they are successively used. Multiplicity of outlets also permits tools to be used at any convenient position along the bench, without having the inconvenience of long extension cords. In this installation, raceway was surface-mounted against the cinder-block walls, then receptacles were positioned and wired, and covers and end caps were installed. Note that the surface duct is fed from a central junction box that obtains power by means of a conduit feeder installed in the wall.

focused upon the growing category of underfloor raceways. And this category, a major sub-division, concerns duct systems that (1) permit office layouts to be altered as departmental changes in activity, methods and personnel develop; (2) eliminate the necessity for hazardous and unsightly extension cords; (3) keep walls and ceilings free of outlets; and thereby (4) contribute to overall economies in management and maintenance.

Towards this end, underfloor duct systems (both metal and fiber) constitute versatile distribution mediums that can be obtained as single-, double-, or triple-cell runs, and can be installed as 1-, 2-, or 3-level systems with a wide variety of junction boxes, duct inserts and surface outlets available to satisfy all normal electrical needs. Moreover, with concealed raceways underlying all possible areas of utilization, subsequent service can be established or altered without further disturbance of existing physi-



HIGH AND LOW TENSION wiring is segregated in this box by means of interior partitions, although access to both systems is possible by removal of common cover. Liberal dimensions of box facilitate pulling of wire and permit large-radius bends when circuitry changes direction.

cal features in an established office. Since underfloor ducts are avail-

able in either metal or fiber with duct cross-sections offering a variety of rectangular and oval shapes in various dimensions, designers have a liberal choice of components to meet criteria of capacity, economy and construction. Similarly, since junction boxes may be obtained as single-, double-, or triple-tier assemblies, with either open or partitioned interiors, it is possible to either isolate several electrical services within the same general duct system, or to permit related circuitry to change direction or elevation at any junction-box location.

Such boxes and covers are easily adjustable for height and may be leveled by means of rings and screws; watertight gasketed plates are available to exclude moisture from these junction points; unused box openings can be blanked off and sealed when not in use. Cover plates may be obtained either as flat assemblies for flush floor installations or may be recessed to receive floor-harmonizing finishes such as terrazzo, linoleum, tile or concrete.

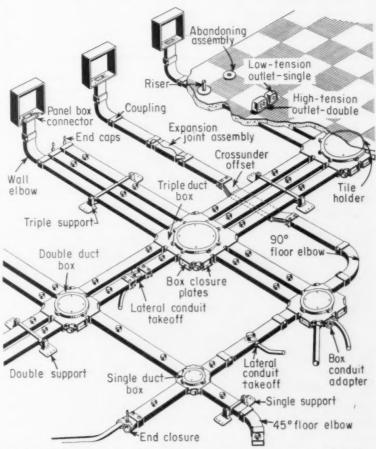
In selecting and locating components, four general floor layouts should be considered: (1) full coverage of all usable areas, establishing provisions for all requirements anticipated during the lifetime of the structure; (2) full coverage for certain portions of the floor, an approach with somewhat less scope but frequently establishing an acceptable compromise between essential service and economy; (3)

#### **NEC Requirements** RACEWAYS: Underfloor (Metal and Fiber); Article 354

Underfloor raceway systems must comply with all general requirements for wiring methods as previously defined by the summary of Article 300. They are not permissible in hazardous locations, commercial garages, storage battery rooms or locations subject to corrosive

Depending upon construction and width, underfloor raceways either may be laid flush with concrete floors and covered by linoleum or equivalent floor covering, or they may have to be physically protected by various thicknesses of concrete or wood flooring. Where they have open bottoms, underfloor raceways must be placed upon smooth concrete pads and mechanically secured to same, being located in concrete fill between rough and finished floorslabs only.

In the installation of underfloor raceway components, centerlines of raceways must coincide with centerlines of junction boxes, this alignment maintained by securing parts mechanically. Markers must be installed at raceway terminals to define lines and limits of ducts, while dead ends must be closed and sealed. Wherever practicable, raceways and fittings must be so arranged as to eliminate low points where water can accumulate. Junction boxes and inserts must be leveled to floor grade and made watertight. And, when raceways are of metal, junction boxes and inserts must likewise be of metal and made electrically continuous with the entire raceway system.



WITH ALL DUCTS mounted at same elevation, junction boxes may be obtained to accommodate either one, two, or three ducts on each side, closure plates sealing unused openings. Duct supports likewise are available for one or more cells, while wide variety of accessory components promotes flexibility in layout and variety in service facilities.

#### **NEC Requirements**

## RACEWAYS: Cellular Floor (Metal and Concrete); Articles 356 and 358

By code definition, cellular floor raceway systems consist of hollow cellular floor spaces, together with suitable approved fittings for the safe enclosure of electrical conductors. In such systems, a cell (either metal or concrete) is defined as a "single enclosed tubular space in the flooring," while a header or header duct is defined as a "raceway running at right angles to the cells, providing access to same and permitting the installation of electrical conductors between cells and related distribution centers." When used as electrical distribution mediums, cells must be identified as to location and intended purpose by suitable markers that penetrate floor coverings, while junction boxes and inserts must be leveled and sealed against water in the same manner prescribed previously for underfloor raceways. Also, like underfloor raceways, they must comply with general requirements for wiring methods and are limited, as to permissible use, to the same extent.

In the case of cellular *metal* floor raceways, junction boxes and inserts must be electrically bonded to the metal flooring. And, in the case of cellular *concrete* floor raceways, inserts must be of metal and contain grounded-type receptacles which are positively grounded via suitable fittings and conductors to metal header ducts. Headers, in turn, are electrically continuous through their entire lengths, and are electrically bonded to enclosures of distribution centers by means of approved metallic ducts and fittings. Such header ducts in cellular concrete raceway systems must be installed in straight lines at right angles to cells; mechanically secured to the top of the precast concrete underflooring; leveled so that their upper surfaces are flush with finished floorslab surfaces; properly closed at ends with metallic fittings; and sealed throughout against water penetration.

Acres factors

Acres

**PHANTOM VIEW** of cellular metal floor shows possibility for combining cells of different widths in the same unified floor structure, thereby providing larger cells for purposes such as air plenums, while retaining standard sized cells for electrical wiring. Note insulation beneath air ducts, undercoating of fireproofing material, and top slab of concrete fill enclosing header duct. Electrical distribution is from panel flange at right, through header to access boxes, down into related cells, then through cells to inserts beneath floor outlet heads.

perimeter systems that, in effect, transfer service outlets from exterior walls and corridor mouldings to periphery floor sections; and (4) various special layouts such as are found in banks and like occupancies.

Location of components generally places junction boxes at all points where ducts change direction or elevation, intersect or connect with distribution-center ducts, headers or home runs. JBs are likewise recommended along long straight runs, at intervals not exceeding 50 ft, to facilitate wire pulling.

After boxes have been positioned accurately and leveled to coincide with finished-floor elevations, they are secured in place by grouting, tying or tapping; then connecting ducts and supports are similarly aligned, leveled and anchored to base slabs. Insert tops may be leveled either to finished-floor levels or slightly beneath them, so that final cement surfaces can be thinly troweled over. After screws and connections have been tightened, home runs (when employed) are installed, and the installation is ready for final pour.

To support ducts at desired elevations, saddles are adjustable for height. And, since insert collars of various heights and cross-sections are likewise available to conform with depth of duct-burial and the nature of local electrical needs, underfloor duct systems may be exactly "tailored" to suit specific construction conditions. Duct-related components also include numerous types of couplings, expansion joints, horizontal and vertical elbows, conduit takeoffs, caps and scores of standard service fitting. This variety permits distribution systems to be readily adapted to meet such diverse construction conditions as exist with fill on beam-and-slab, wire-mesh reinforced forms on bar joists, single-pour slabs on permanent steel forms, or floor construction involving reinforced-concrete joints.

#### Cellular Floor Raceways

Cellular flooring provides the same basic electrical distribution flexibility as that offered by underfloor raceway systems. However, since flooring sections (metal or concrete) now constitute an integral overall load-bearing part of the building construction, far more cells are available for distribution use, and positioning of floor outlets is

practically unlimited in possibil-

This type of construction permits cells to be used variously as wiring raceways for power, light, telephone and intercom services, and as routing mediums for piping related to steam, gas, water, air, drainage or other non-electrical services. All such services are logically segregated by confining them within separate cells, cells then being identified as to their purpose and location by suitable markers that extend upward through floor coverings.

As indicated by an accompanying illustration, metal cellular floor sections having cells of different widths can readily be combined into unified flooring installations, thereby providing large-volume cells for such purposes as air-conditioning plenums, while still utilizing standard cross-section ducts as electrical raceways.

Since metal cellular floor sections are secured to a building's structural steel beams by means of bolts or welding, all raceways thereby become bonded to a mass grounding medium. And, since all related floor inserts, receptacles, header ducts and junction boxes are electrically bonded to the cellular floor, electrical grounding is continuous and positive throughout the installation.

Header ducts, installed directly above, in contact with, and at right angles to floor cells, provide wireways between distribution panels and cells related to them. Wiring passes from headers down into cells through coincident openings drilled through access-box bottoms and floorcell tops. Tops of access boxes (or handholes), set flush with finished floorslabs, are equipped with ample-area covers (obtainable as round, square or oblong units) that may readily be removed to facilitate wire pulling and fishing. Ends of headers, of course, are capped and the entire installation made waterproof by approved gasketing, sealing and coatings.

Cellular floor components are precision made, thereby minimizing installation problems. And, with a liberal selection of header lengths and cross sections, couplings and connecting accessories, leveling and adjustment screws, special cutting and installation tools to assist construction crews, on-the-job fabrication problems are generally non-existent or relatively minor in nature.

FLEXIBILITY AND DIVERSITY of wireway components is illustrated in this isometric drawing showing conduit end fitting (1), crossover pullbox (2), square junction box (3), 90-degree pullbox elbow (4), 90-degree elbows (5), long and short nipples (6 and 7), 45-degree elbows (8), T-shaped pullbox (9), different lengths of sections (10, 11 and 12), couplings (13), box-connecting coupling (14), slip fittings (15), and end plate (16).

Another type of cellular flooring consists of monolithically precast reinforced-concrete beam-slabs containing large-area tubular cells that constitute effective, approved electrical raceways.

Advantages of concrete cellular floors are several, since (1) long available lengths of beam-slabs permit construction of wide clearspan bays between walls and columns, (2) erection of lightweight, dry floor sections is fast, (3) structural framing is minimized, (4) work-decks become available to all trades almost immediately, and (5) these structural concrete floors require no additional undercoating for fire-proofing purposes.

As is the case with metal cellular floors, wiring related to concrete cellular flooring is carried from distribution centers to cells through metal header ducts although, since cells are non-metallic, the headers rather than the cells then become the basic mediums for grounding floor inserts and receptacles via appropriate connections and grounding wires.

After standard header ducts are positioned between distribution panels and related cells, concrete fill is leveled flush with tops of headers and the finished floor surface is then usually covered by linoleum or other equivalent covering. As indicated by an accompanying sketch, beam-slabs are notched along either side so that when the layer of concrete fill is poured, concrete settles into these notched

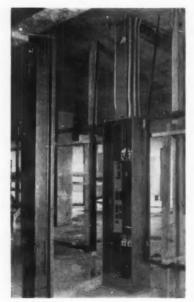
keyways, thereby serving to unify the complete floor structure.

Since access holes may be readily drilled into cellular concrete beamslabs by means of diamond-tooth core saws, location of openings beneath header-duct hand-holes and floor receptacle outlets is a fast operation. And, since cells are identified as to purpose and position by visible markers or escutcheons, location of raceways is no problem. Of course, since cells are non-metallic, grounded-type floor receptacles used in such installations are bonded to metal header ducts through separate grounding wires, while headers in turn are made electrically continuous with distribution panel enclosures by means of approved metallic fittings with sufficient conductivity.

#### Wireways

Wireways, consisting of prefabricated metal ducts or troughs having covers which are either hinged, snapped or screwed into place, provide large-capacity raceways for electrical circuitry. And, since covers are continuous for the full lengths of assemblies, accessibility to conductors (for purposes of augmenting or altering wiring arrangements) results in maximum wiring flexibility.

Although wireways may not be installed in hazardous areas, hoistways, storage battery rooms or where exposed to severe corrosive vapors or mechanical abuse, they



SPECIAL DUCTS were constructed in this instance to provide enclosed feeder raceways between tierred distribution and control panels in commercial building. Due to unusual design of this reinforced concrete structure, thin-slab openings through slabs had to be limited to cross-section. Since specific precedence was lacking, consulting engineer worked cooperatively with electrical inspector to insure full compliance of design and construction with intent of code. Panels, connecting "stacks," and branch conduits extending upwards to overhead slab were then incorporated into corridor walls.

have definite advantages where dry, exposed locations are under consideration. Outlets may be placed at any convenient location where current is required (for portable elec-

#### **NEC Requirements**

#### Wireways (and sheet metal troughs); Article 362

Wireways or sheet metal troughs having hinged or removable covers (designed to house and protect electrical wires and cables which are laid in place only after wireways have been installed as complete systems) may be used only for exposed work in dry locations where not subject to mechanical injury, or corrosive vapors. Neither may they be used in hazardous locations or in storage-battery rooms. Unless special permission is granted by the electrical inspector, wireways must be securely supported at intervals not exceeding 5 ft, and in no instance may support intervals exceed 10 ft.

Wireways may extend transversely through dry walls, provided sections passing through are in unbroken lengths. Dead ends of wireways must be closed; wireways must be marked and arranged so as to identify the manufacturer upon completion of the installation, and all extensions from wireways must be made either with surface metal raceways, rigid or flexible metal conduit, EMT or armored cable.

#### Auxiliary Gutters; Article 374

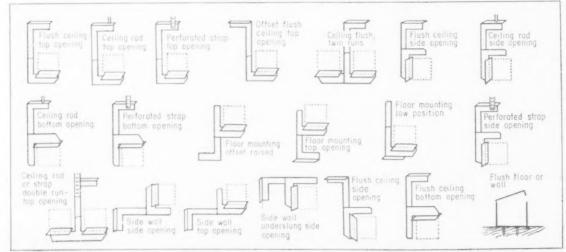
Auxiliary gutters (modified wireways used to supplement wiring spaces at meter centers, distribution centers, switchboards and similar points of interior wiring systems) may be used to enclose conductors but not switches, overcurrent devices or other apparatus or appliances. Except in elevator work, such gutters cannot extend more than 30 ft beyond equipment they supplement. Gutters must be supported throughout their entire lengths, at intervals not exceeding 5 ft, and covers must be securely fastened.

tric tools, small motors, heating devices, etc.), and extensions may take the form of surface metal raceway, conduit, electrical metallic tubing, or armored cable. Moreover, wireways can be used as auxiliary gutters, as defined in an accompanying code summary.

Since wireways are manufactured in various standard sizes (4 by 4, 6 by 6 in. in cross-section; in 2-5- and 10-ft lengths, for example) and since non-standard dimensions may be specified on special orders when necessary, installations can be de-

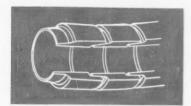
signed to comply with most local wiring demands. Moreover, each section is provided with a removable coupling at one end that serves to unify the entire assembly and (together with intermediate cable supports) also serves to hold conductors in place prior to the installation of covers.

These same couplings and cable supports likewise take considerable strain from hinges, latches and screws after covers have been installed and closed, thereby preserving these parts and simplifying sub-



**STEEL ENCLOSED** wireways and auxiliary gutters may be supported in dozens of ways so that hinged or screw covers may be opened from top, bottom, or side, as desired. Special

hangers also permit enclosures to be mounted against walls or ceilings, suspended from rod hangers or perforated straps: offset, underslung or mounted in multiple runs.



FLEXIBILITY IN LAYOUT and installation of asbestos-cement ducts is possible with use of bend segments having male taper on one end, female taper on the other, each machined at an angle of 2½ degrees to provide a combined bend up to 5 degrees. By using segments singly or in combinations, bends of any desired degree can be obtained to clear unexpected obstructions or accommodate revisions in original layouts. Other standard fittings include 45- and 90-degree bends, sweeps, curved sections, laterals, tees, elbows and deflection couplings.

sequent openings and closings of the assemblies.

Concentric-type knockouts at frequent intervals are provided for the convenient location of outlets or extensions, while accessory fittings include end caps, expansion couplings, pull boxes, closure plates for blanking unused openings in same, several degrees of curved elbows, and several types of hangers and bracket supports. This latter variety permits wireways to be installed with covers located at tops, bottoms or sides.

#### **Underground Raceways**

In addition to metal conduit, underground distribution systems may be contained satisfactorily in asbestos-cement or fiber ducts, while numerous relatively recent installations using plastic conduit likewise are gaining high acceptability. Underground distribution has several advantages for, in addition to leaving landscapes unmarred by poles and aerial cables, they isolate and minimize accident hazards. permit unobstructed ground-level operations, and increase currentcarrying capacities of cables by minimizing ambient temperatures. However, underground distribution is not always feasible when local conditions involve such problems as excessive rock, corrosive soils, or future construction plans which would dictate subsequent removal or extensive alterations to the underground system.

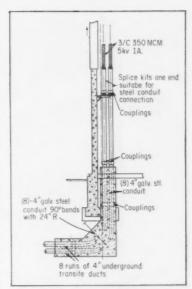
All mediums noted above have various plus-values to recommend their use. For example, where unusually heavy stresses and strains are expected or where raceways are to be forced beneath roadways or sidewalks, steel and aluminum conduits provide required resistive strengths. And, if installed beneath water tables or subjected to corrosive soil conditions, added protection may be obtained through the use of water-resistant asphalt coatings or encasing concrete envelopes.

Advocates of asbestos-cement ducts point out that these products also offer reasonable mechanical strength and are permanent, incombustible, resistant to corrosive action, are non-metallic, unaffected by electrolysis, rust or rot, and cannot burn under short-circuit conditions. Two wall thicknesses are available, thereby permitting extra heavy walls to be selected when a few ducts are to be buried directly in the earth, or offering thinner sections when banks of ducts are to be concrete-sheathed. Concrete sheaths therefore permit economic savings in duct purchase and also provide mechanical compressive strength and solid barriers between adjacent circuit-carrying ducts.

Fiber ducts likewise have two wall thicknesses for similar direct-burial or concrete-sheathed installations; have equivalent non-metallic resistive characteristics; have full lines of bends, fittings and end bells for fast, efficient installation and can be obtained up to 6 in. in 10 ft lengths.

Use of the longer lengths naturally reduces the number of joints and, in installations involving several miles of ductwork, this reduction of joints can be a definite labor-saver. Several manufacturers of fiber duct also offer flush tapered couplings having the same outside diameters as the conduits themselves, thereby permitting one conduit to be laid directly atop another.

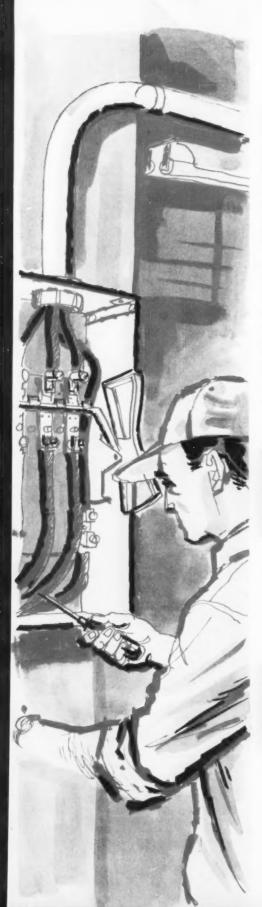
While relatively new in use, semiflexible plastic raceways have UL approval as underground electrical raceways and have been used satisfactorily for both primary (5-kv) and secondary distribution. They may be buried directly without concrete coverings: are considerably lighter than either metal. asbestoscement or fiber: will not rust, pit, corrode or support combustion: require no additional coatings, painting or linings; are easily handled and joined; and may be bent to bypass rocks and stumps or to make large-radius turns without requiring supplemental fittings.



UNDERGROUND TRANSITE DUCTS carry primary power from outdoor substation beneath building wall, then connect with galvanized steel bends, couplings and conduit to sweep up inside structure Note continuation of concrete envelope to point above interior floor level, also 2-ft radius of underground bends to facilitate cable pulling.



INSTALLATION of asbestos-cement ducts shows use of lightweight 10-ft sections, variety of couplings, bends and supporting saddles, use of sealing compound and tie rods to maintain duct alignment prior to pour of massive concrete encasing work. With many fittings available to simplify complicated installation, incombustible casings to confine possible arcs and protect adjacent feeders from heat and flame, plus inorganic, non-metallic, corrosion-resistant construction to preclude rust and rot, prevent electrolysis and dissipate heat rapidly, such ducts provide widespread adaptability.



### **Switches**

WIDE range of types and sizes of switches are used for control and isolation of circuits and loads in modern electrical systems. Such switches are readily classified according to construction, operating mechanism and application. Proper selection and installation of switches depend upon a clear understanding of the many types and the differences between them.

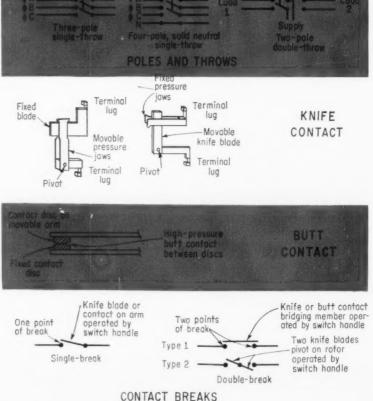
Classification on the basis of fundamental construction and operating characteristics can be made as follows:

Number of Poles—In any switch, there are one or more line terminals and a corresponding number of load terminals. These terminals are called "poles". The number of line or supply terminals determines how a switch will be classified according to number of poles. The number of poles corresponds to the number

of conductor paths through the switch. There are 1-, 2-, 3-, 4- and 5-pole switches in use today.

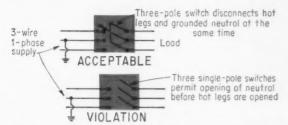
In grounded electrical systems, common practice calls for carrying the grounded conductor unbroken through switches. There are two ways to do this. First, a switch with a number of poles equal to one less than the number of wires can be used. Then, the neutral conductor can just be carried directly through the switch enclosure and the other conductors connected to the switch poles. The second way is to use a "solid-neutral" switch. This is a switch with a number of poles (line terminals) equal to the number of wires carried through the switch, but with a solid conductor strap between one of the line terminals and the corresponding load terminal. The neutral conductor is connected to these terminals. The switch opens and closes

#### SWITCH CHARACTERISTICS

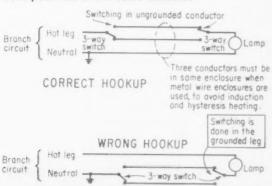


#### **GENERAL CODE RULES ON SWITCHES**

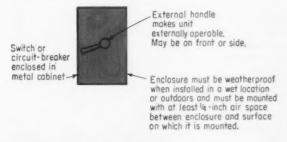
1. No switch or circuit breaker shall disconnect the grounded conductor of a circuit unless it simultaneously disconnects the ungrounded conductor or conductors or unless it is so arranged that the grounded conductor cannot be disconnected until the ungrounded conductor or conductors have first been disconnected.



2. Three-way and 4-way switches shall be so wired that all switching is done only in the ungrounded circuit conductor. Wiring between switches and our lets shall, where in metal enclosures, be run with both polarities in the same enclosure.



 Switches and CBs shall be of the externally-operable type enclosed in metal boxes or cabinets, except pendant and surface type snap switches and knife switches mounted on an open-face switchboard or panelboard.



only the ungrounded conductors.

Number of Throws—A switch may have one, two or more closed positions. Most switches are single-throw type, with one closed position. Double-throw switches are commonly used to switch a load from one supply to another or to switch a supply from one load to another. Multiple-throw switches include rotary or dial switches, com-

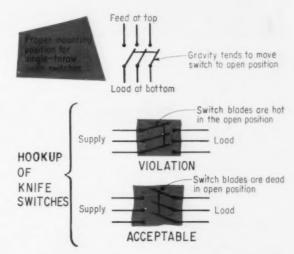
monly used in control or instrument applications.

Type of Contact—Switches can also be classified according to the manner in which they open and close the current path. The common types of contacts include:

1. Knife-blade pressure jaws.

2. High-pressure "butt" between a set of movable contacts and a set of stationary contacts.

- 4. A switch or CB must be used in a weatherproof enclosure when installed in wet locations or outdoors. The enclosure must be placed or equipped to prevent moisture or water from entering and accumulating within it.
- 5. Single-throw knife switches must be so placed that gravity will not tend to close them. Blades must be dead in the open position.



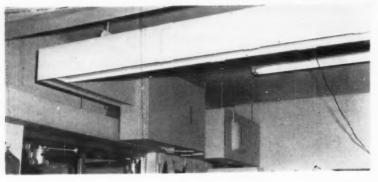
6. Switches and circuit breakers, so far as practicable, must be readily accessible and must be grouped together instead of spread out. The code definition for readily accessible should be clearly understood:

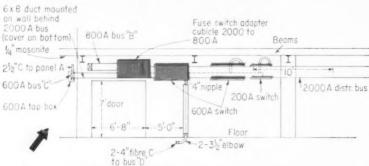
"Readily Accessible: Capable of being reached quickly, for operation, renewal or inspections, without requiring those to whom ready access is requisite to climb-over or remove obstacles or to resort to portable ladders, chairs, etc."

- 7. A manually-operated circuit breaker may serve as a switch if it has the number of poles required for such switch.
- 8. Knife switches rated at more than 1200 amps, up to 250 volts and at more than 600 amps, from 251 to 600 volts, must be used only as isolating switches and must not be opened under load. Circuit breakers or special switches must be used for load-break applications in that range. However, at lower ratings knife switches may be used for general-purpose applications and may be opened under load.

3. Enclosed liquid mercury "bridging" two contact points.

Contact Breaks—When opening a current path, a switch may break contact at one or two points in the current path. If it breaks at one point in each pole, it is called a "single-break" type. If the switch breaks contact at two points in each current path, it is a "double-break" type.





**FUSED SWITCH** adapter cubicle (the large enclosure) is used here at point of reduction from a 2000-amp busway, coming through wall in background, to an 800-amp busway in foreground. A 600-amp tap switch, at right of adapter cubicle, feeds down, under the floor slab and up to a 600-amp busway in another area. This equipment is a part of an extensive busway distribution system in the basement of a department store. Diagram shows layout, with arrow indicating angle.

Method of Operation — Switches may be operated (opened and closed) by several methods: manually, by hand movement of the switch handle; electromagnetically, by use of an electromagnetic solenoid to move the contact member; by motor drive; or by automatic application of an external mechanical force, such as pressure in a pressure-operated switch.

#### Types of Switches

Based on particular application requirements, switches are designed in many types. A close look at the characteristics of these common types of switches greatly clarifies selection and installation.

#### General-Use Switches

General-use switches are intended for use in general distribution and branch circuits. They are rated in amperes and are capable of interrupting their rated current at the rated voltage. The enclosed type of general-use switch is commonly called a "safety switch."

Enclosed general-use switches are made in three different con-

#### SWITCH ENCLOSURES

Types of enclosures used with enclosed switches are as follows:

Type 1—General Purpose

A general-purpose enclosure is intended primarily to prevent accidental contact with the enclosed apparatus. It is suitable for general-purpose application indoors where it is not exposed

to unusual service conditions.

Type 3R—Raintight

A raintight enclosure is intended primarily to meet the requirements for raintight apparatus. It will also meet the requirements for drip-tight, splash-proof and moisture-resistant. It is suitable for general application outdoors where sleetproof construction is not required.

Type 4-Watertight

A watertight enclosure is designed to exclude water applied in the form of a hose stream. It is suitable for application where the apparatus may be subjected to a stream of water during cleaning operations and the like. It will also meet the requirements for drip-tight, splash-proof and moisture-resistant.

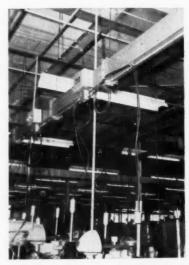
Type 7—Class I Hazardous Locations, Groups A, B, C or D—Air Break

These are enclosures for use in corresponding hazardous locations from the National Electrical Code. Circuit interruption is made in the air.

Type 9—Class II Hazardous Locations, Groups E, F or G
These are for use in corresponding hazardous locations.

Type 12—Industrial Use

An industrial-use enclosure is designed for use in those industries where it is desired to exclude such materials as dust, lint, fibers and flyings, oil seepage or coolant seepage. It meets the requirements for dust-tight and oil-tight.



BUSWAY TAPS are made through fused switches into attached boxes in which leads from load side of switch are spliced to a number of type S, 4-wire dropcords to a group of small motors. Each motor has its own starter and running overload protection. Branch circuit, short-circuit protection and group disconnect are provided by the single fused switch for each group. A separable connector at the cord end affords individual disconnect.

structions to satisfy the requirements of heavy-duty, normal-duty and light-duty applications. Basic NEMA data are as follows:

Heavy-duty switches, known as type HD, are designed for severe conditions of use-frequent operation of contacts and long periods of use. Their performance and continuity suit them to use in mass industries. Typical production heavy-duty switches are rated from 30 amps up to 1200 amps (30, 60, 100, 200, 400, 600, 800 and 1200 amps) up to 600 volts ac.

Normal-duty switches, known as type ND, are designed for less severe conditions of application. They are widely used for industrial, institutional and commercial applications where service demands are not severe. Typical applications include motor branch circuit disconnect and service entrance. They are also rated 30, 60, 100, 200, 400, 600, 800 or 1200 amps up to 600 volts ac.

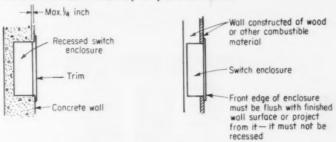
Light-duty switches, known as type LD, are designed for applications where switch operation will be infrequent. They are commonly used for service entrances in residences and for load and circuit disconnects in commercial, light industrial and farm-type buildings. Available ratings are up to 600 amps, up to 240 volts ac.

Switches are rated in amperes in all cases. However, types HD, ND and LD switches are also rated in horsepower. In the HD and ND types, switches rated 400 amps or less and 250 volts or less and switches rated 200 amps or less and above 250 volts are required by NEMA standards to be capable of interrupting motor locked-rotor current. Type HD switches must be able to interrupt locked-rotor current equal to ten times the fullload current ratings given in the NE Code for ac motors of corresponding hp rating. Type ND and LD switches must be able to interrupt current equal to six times fullload current of motors of corresponding hp rating. For dc motors, HD and ND switches must be able to interrupt four times full-load current.

General-use switches are made in non-fusible and fusible types. The non-fusible type is used for disconnect and control of feeder and branch circuits where overcurrent protection is provided in other devices. The fusible type is equipped with fuseholders to accommodate insertion of fuses in the ungrounded

#### CODE RULES ON SWITCH ENCLOSURES

1. In walls of concrete, tile or other non-combustible material, cabinets shall be so installed that the front edge will not set more than 1/4 in back of the finished surface. In wood walls or other combustible material, they may not set back.

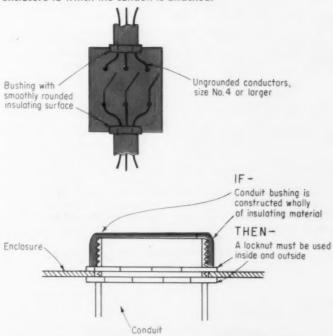


2. Unused openings in enclosures must be effectively closed by metal plugs or plates to provide protection equivalent to that of the wall of the box.

3. Where ungrounded conductors in sizes No. 4 and larger enter a raceway in a switch enclosure, the conductors shall be protected by a substantial bushing providing a smoothly rounded insulating surface, unless the conductors are separated from the raceway by substantial insulating material securely fastened in place.

Where conduit bushings are made wholly of insulating material, a locknut shall be installed both inside and outside the

enclosure to which the conduit is attached.



4. Switch enclosures shall be selected to accommodate all conductors installed in them without crowding.

legs. Fused switches are used to provide disconnect and overload and short-circuit protection for feeders branch circuits. switches take cartridge fuses from 30 amps up. Light duty switches are available for use with plug fuses up to 30-amps.

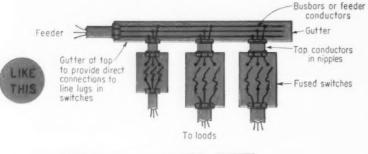
A fusible switch can take either standard NE Code fuses or timedelay fuses-up to the rating of the switch. Because a given size of time-delay fuse can hold on the starting current of a motor larger than that which could be used with a standard fuse of the same rating.

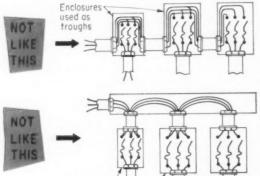
#### WIRING A GROUP OF SWITCHES

Problem: A number of branch circuits or subfeeder circuits are to be tapped from a feeder at one location, using fused switches for disconnects and short circuit protection.

Solution: Bring feeder conduit into a suitable auxiliary gutter and tap from feeder conductors in gutter through the

individual enclosed safety switches.





#### NEC RULE SECTION 373-8

Switch enclosures shall not be used as junction boxes, troughs or raceways for conductors feeding through or tapping off to other switches, unless designs suitable for the purpose are employed to provide adequate space.

DISCONNECT SWITCHES for branch circuits are mounted on an angleiron frame between two of the horizontal steel channel members which support the corrugated steel wall of a metal fabricating plant. Note the method of circuit makeup: the feeder to the group of fused switches comes into the junction box shown above the center switch; a tap is made to each switch from the JB; then the branch circuits are carried to their individual motor loads. This method is an alternative to that in which taps to a group of switches are made from an auxiliary gutter at the end of the feeder as shown in sketch at left. For two or three 30-amp disconnect switches, a JB would be less expensive than a gutter.

fusible switches are given two hp ratings—one for use with standard fuses, the other for use with timedelay fuses. For example, a 30-amp, 2-pole, 240-volt ac switch is rated at 1½ hp for single-phase motor application using 30-amp standard NEC fuses. But, using 30-amp time-delay fuses, the same switch

Enclosures

junction boxes

used as

is rated at 3-hp for single-phase motor applications. Similarly, a 200-amp, 3-pole, 240-volt ac switch is rated at 25-hp for 3-phase motor applications using standard fuses and at 50-hp using time-delay fuses.

Non-fusible switches have hp ratings which correspond to the hp ratings of the same size and type

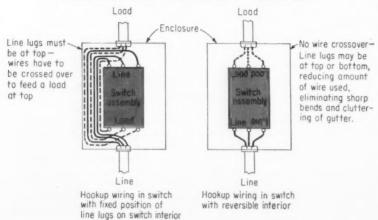
of fusible switch using time-delay fuses. That is, a non-fusible switch has the higher of the two hp ratings assigned to the same switch in the fusible type.

Heavy-duty switches are available with either front-mounted or side-mounted operating handles. Front-operated switches can be grouped closer together where space is limited. Normal-duty and light-duty switches are generally side-operated. Some light-duty switches are made with a front-operated toggle handle.

Typical features of modern general-use switches include the following:

1. Quick-make, quick-break operation of contacts to minimize contact wear due to arcs, better suiting the devices to interrupting inductive load currents and closing on high inrush currents. Types HD and ND switches have spring-loaded mechanisms to provide effective quick-make, quick-break contact operation. LD switches may have spring assist.

#### HOOKUPS FOR TWO TYPES OF SWITCHES





MOTOR DISCONNECT switches motor branch circuits from a busway in a second-floor room housing refrigeration compressors for display cases on the main floor of a supermarket. A 225-amp busway run is supplied by 250 MCM conductors in conduit which terminate in a size 5 magnetic contactor in an enclosure at the supply end of the busway. The contactor feeds the busway and is controlled by a time switch in its coil circuit. Compressor units are racked two high for the length of the room. Each plug-in fused tap switch provides short-circuit protection and disconnecting means for a circuit to a compressor. Magnetic motor controllers for the compressors are mounted on the rack, with their coil circuits run to temperature sensing devices in the display cases downstairs.

2. Visible blade construction to readily indicate position of switch contacts, whether "ON" or "OFF," and to facilitate inspection and maintenance of parts.

3. High-pressure fuseholders to tightly clamp fuses in position, reducing contact resistance and consequent heat rise and providing longer, more reliable fuse life and lower switch maintenance.

4. Interlocking cover with handle to prevent opening the cover with the switch in the closed position, providing increased safety to personnel, with a means for authorized persons to defeat the interlock.

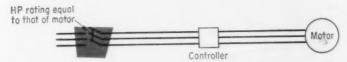
5. Padlocking provisions to positively lock the switch with contacts in the "OFF" position, for safe maintenance in electrical systems.

6. Double-break contacts to provide the better arc suppression of breaking contact at two points in each path of current flow, for cooler operation and extended contact life.

7. Arc quenchers or chutes for cooler, faster current interruption.

#### MOTOR DISCONNECT SWITCHES

 A switch used for disconnecting a motor and its controller from its source of supply must be a motor-circuit switch rated in horsepower.



2. For stationary motors rated at 2 hp or less and 300 volts or less the disconnecting means may be a general-use switch with an ampere rating at least twice that of the full-load current of the motor.

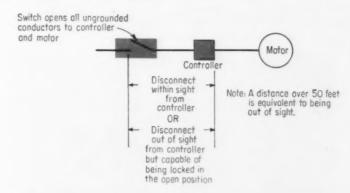


Or, on ac circuits only, an ac general-use snap switch may be used as a disconnecting means for a motor with full-load current not in excess of 80% of the ampere rating of the switch.

3. For stationary motors rated at more than 50 hp, the disconnecting means may be a motor-circuit switch rated also in amperes, a general-use switch or an isolating switch.



4. A motor disconnect switch must disconnect both motor and controller from all ungrounded conductors, must indicate whether it is open or closed, must be readily accessible and must be located within sight from the controller location or be arranged to be locked in the open position.



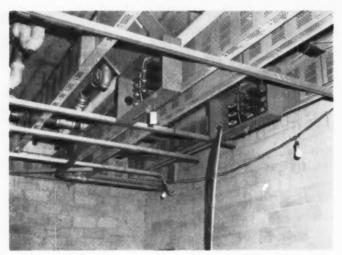
8. Removable switch interior to provide easy mounting of the enclosure and ready, unobstructed pulling of wires into the switch enclosure

9. Circuit-breaker contact mechanism in larger sizes of heavy-duty switches (200 amps, up) to provide efficient load interruption up to 12 times switch rating, using individual pole-springs and deionizing archutes and suited for use with current-limiting fuses at points of very high short-circuit duty.

Although most applications of

general-use switches call for singlethrow types, the double-throw switch finds frequent application for manual transfer tasks. Heavy-duty and light-duty double-throw switches are made in fusible and non-fusible types for manual load or supply transfer or for motor-reversing. Some such switches are hp rated for motor use.

Accompanying illustrations show the use of general-use switches for feeder and branch circuit disconnect, motor disconnect and service entrance use.



**BUS TAP SWITCHES** are 200-amp fused disconnects for No. 2, 3-phase, 480-volt circuits in 2-in. conduit to 100-amp power receptacles in an industrial area. Busway is rated at 1000 amps and will be concealed above a suspended ceiling in this office area. This use of busway in a dropped ceiling was ruled not in violation of the NE Code prohibition on concealment of busway, because ceiling panels can be readily removed.

#### **Isolating Switches**

Isolating switches are used to isolate a circuit or load device from its source of power. Such switches can be opened only after the circuit has been broken by some other switching device; they are not capable of interrupting the circuit current. Such switches are commonly used to isolate motors for repair or

inspection, and they can often be locked in the open position. Both indoor and outdoor type isolating switches are available, for mounting either open or in an enclosure.

Section 430-109 (d) of the NE Code permits the use of an isolating switch as a disconnect means for stationary motors rated at more than 50 hp. It notes that isolating switches for such motor discon-



**SERVICE LAYOUT** in a small headquarters building for a city fire-alarm system is mounted on the inside of a solid brick outside wall. The 400-amp fused switch in the center is the service disconnect and is fed through the wall by a  $2\frac{1}{2}$ -in. service conduit coming into the back of the switch. Service conductors are run from the load side of this switch into "normal" terminals of the automatic transfer switch at left. The "emergency" terminals of the ATS are fed by a gasoline-electric generator. Conductors from the "load" terminals of the ATS are carried up to the horizontal autter from which the panels are topped.

nect applications must be plainly marked "DO NOT OPEN UNDER LOAD." This would apply to any switch not capable of interrupting stalled-rotor current of the motor.

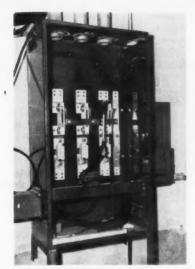
#### **High Capacity Switches**

A wide range of types and sizes of switches is available for use in modern high-capacity feeder and service entrance applications. In the range from 200 amps to 1200 amps, up to 600 volts, service entrance and feeder applications can use heavy-duty, quick-make, quick-break fusible safety switches. In the range from 1200 amps up to 6000 amps, either the bolted pressure switch or the power circuit-breaker type load interrupter is used.

Many high-capacity secondaryvoltage service entrances make use of bolted pressure contact switches. Typical switches of this type are made in sizes from 1200 amps up. They are generally manually operated with external handles. Most common application is in a general-purpose, ventilated enclosure, either individually enclosed in an incoming line section or combined within a main secondary switchboard. Such a switch is generally used with high-capacity fuses of either the current-limiting or noncurrent limiting type, depending upon bus bracing and coordination requirements.

Modern bolted pressure switches are rated for breaking load, withstanding let-through thermal and magnetic stresses during fuse operation on short circuit and for closing against a short circuit. Typical units are rated for load breaks up to 150% of the nameplate current rating, at 75% to 80% power factor. Design is such that after a large number of such rated load breaks, the switch is still capable of carrying full-load current continuously without dressing the contacts.

With proper fusing, the assembly is capable of fault clearance through the fuses. With the switch closed and fitted with high-interrupting-capacity fuses, faults well in excess of 100,000 rms amperes at 600 volts can be cleared promptly and safely without damage to equipment or personnel. And the switch and fuse combination can be closed against the same short-circuit fault.



PRESSURE BOLTED SWITCH. rated 1200 amps at 240 volts, 3-phase, is mounted in a ventilated cabinet set on angle-iron legs. This fused switch is used for service disconnect and protection in a commercial laundry and is located in a corner of the building. Service conductors will enter at top-three sets of three 500's with a No. 1/0 neutral for each set. Main feeder conductors will run to distribution panel, adjacent to the switch, at left, through a short section of wireway. Note the welded connection of wireway to switch enclosure.

Another type of high capacity switch for use where currents are in the range of thousands of amperes is the fused interrupter. Fused interrupter switches are made for service entrance and feeder applications for systems under 600 volts. Such a switch is a fully coordinated combination of a circuit breaker mechanism and current-limiting fuses. Characteristics of such a switch are as follows:

1. Increased safety and lower maintenance due to the quick-make, quick-break operating mechanism which makes speed of operation independent of force applied by the operator.

2. Load-interrupting ability in the switch itself up to 12 times rated current and ability to safely close against short-circuit currents.

3. Suitability for use where short-circuit current is as high as 200,000 amps rms symmetrical, with fault interruption accomplished by the fuses.

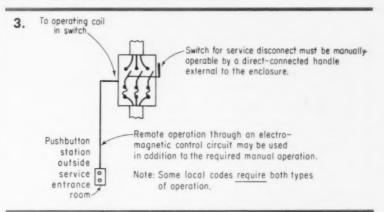
4. Standard provision for electrical operation from a remote control position. Such remote operation is required by some local electrical codes for service entrance application,

#### SWITCHES IN SERVICE ENTRANCES

Point of entry of service entrance conductors

Service entrance switch or switches must be located at a readily accessible point nearest conductor entrance

2. Switches used for service entrance disconnecting means must be approved for use as service equipment.

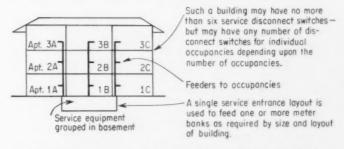


4. Connections which depend upon solder shall not be used to attach service conductors to service switch terminals.

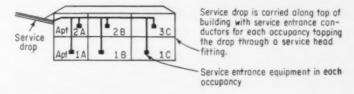
#### SWITCH DISCONNECTS IN MULTIPLE OCCUPANCIES

1. In a multiple-occupancy building, each occupant shall have access to his disconnecting means.

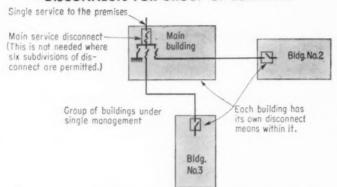
 Multiple-occupancy building having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the disconnecting means consisting of not more than six switches (or six CBs).



3. Multiple-occupancy buildings that do not have individual occupancy above the second floor may have service conductors run to each occupancy. The service disconnecting means in each occupancy may then consist of not more than six switches (or six CBs).



#### DISCONNECTS FOR GROUP OF BUILDINGS



NEC Sec. 230-76 requires that the conductors supplying each building in the above group be provided with a readily accessible means, within or adjacent to the building, of disconnecting all ungrounded conductors from the source of supply.

The meaning of the word "adjacent" in the above rule has often caused confusion in applying the rule. Some authorities permit the use of the feeder switch in the main building as the only disconnect for each feeder to the outlying buildings, providing the switches in the main building are accessible to the occupants of the outlying buildings. There is no definite distance which can be applied to the word "adjacent." Other inspection and engineering authorities prefer a readily accessible feeder disconnect within each outlying building, as shown above, regardless of distance from main building.

Typical low-voltage fused interrupters are rated from 800 amps up to 4,000 amps, continuous. The switching mechanism is based on that used in low-voltage power circuit breakers—the so-called "large air breaker." The complete assembly—switch and fuses—is available in a free-standing general-purpose enclosure or for mounting in a dead-front switchboard.

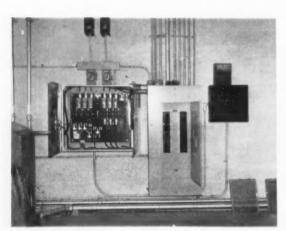
The advantage of the fused interrupter lies in its ability to assure safe and reliable switch interruption of normal current and overload current up to the value of overload current at which the fuses provide automatic, instantaneous clearing of the fault. There is then no possibility of switch operation above the ability of the contacts to safely interrupt fault current. In

the case of a switch with an interrupting ability equal to its continuous rating, there is hazard in operation of this switch on a low-level fault current which is above the switch interrupting rating, but is not high enough to open the fuses before someone could open the switch. Opening such a switch at a current above its interrupting rating could damage or even destroy the switch. In theory, such hazard obtains whenever the switch has an interrupting rating less than the current value at which the fuses operate instantaneously.

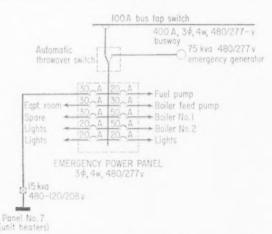
#### Automatic Transfer Switches

A form of contactor control assembly which finds wide use in modern electrical systems is the automatic power transfer switch. Such a switch is used to transfer a power load from its normal source of supply to an emergency source. Typical application would be transfer of a predetermined amount of a building's lighting load from the condition of normal supply by the utility to emergency supply from a diesel-electric generator or a battery bank. Such transfer would take place automatically upon failure of the normal supply. The emergency load would consist only of essential power devices and lighting for safety.

Automatic transfer switches are generally installed in the main switchboard room of a building. Three circuit connections are made

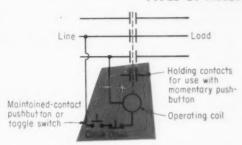


AUTOMATIC TRANSFER SWITCH in an industrial plant provides automatic connection of vital circuits to a dieselgenerator supply upon failure of normal supply. Under normal conditions, a feeder from a 100-amp tap switch on a 400-amp busway in the main plant area is brought into the "normal supply" terminals in the ATS. The "load" is the CB panel



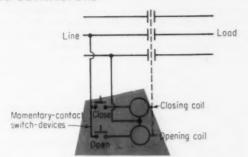
shown, which is normally fed from the 10C-amp bus switch through the ATS. The output circuit of a 75-kva dieselengine generator is connected to the emergency supply terminals of the ATS. When normal power fails, the ATS starts the generator and connects its output to the panel. Equipment is mounted on concrete-block wall in generator room.

#### TYPES OF MAGNETIC CONTACTORS



#### **Electrically-Held Type**

This is essentially a magnetic motor starter without the running overload relays. The coil must be continually energized to hold the contactor closed. De-energizing the coil opens the contactor. This type unit is used for motor starting equipment and for switching lighting and other loads on circuits of stable voltage. Because the contactor depends upon coil voltage to hold it closed, severe voltage fluctuations can drop out the contactor. This characteristic provides low-voltage protection or release, to protect motor equipment.



Mechanically-Held Type

This type of contactor has magnetic operating mechanism to close the contactor by energizing a coil and to open the contactor by energizing a coil. Various coil hookups can be used. The contact assembly is mechanically held in the closed position after the closing coil is de-energized. To open the contactor, the opening coil is energized to oppose the mechanical holding force. Energy is consumed only during opening or closing movement of the contacts. Closed unit holds on voltage dips. This type is commonly used for lighting control.

to the switch assembly—the load to be supplied in case of emergency, the normal feeder to that load and the circuit from the emergency power source. In some cases, the emergency power circuit is derived from a tap on the switchboard mains ahead of the main service switch. The load circuit is commonly a feeder to a panelboard which supplies the essential branch circuits—corridor lighting, stairwell lighting, exit lighting and

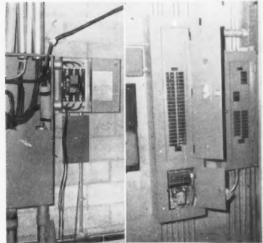
many vital light and power loads in a hospital, laboratory or some industrial operations where loss of certain power would be dangerous.

#### **Magnetic Switches**

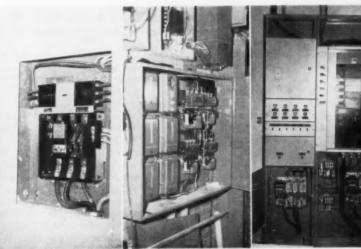
A magnetic switch is an assembly in which the operation of the contacts—the opening and closing—is performed by electromagnetic action. Contacts mounted on the

moving armature are made with or broken from a set of fixed contacts. Operation is identical to that of the magnetic motor starter, with the exception of the running overload relays which are not used in the magnetic switch or contactor.

The basic magnetic switch is operated by energizing its coil to close the contacts and is held in the closed position by maintaining current through the coil. This can be done by using a maintained contact



MAGNETIC CONTACTORS are mounted in a number of ways, depending upon the type of equipment with which they are associated: (L-R) 1. In an individual enclosure at a convenient point in the run of circuit conductors to be controlled, as shown here where the unit is operated by a carrier-frequency relay below it to control outdoor floodlights; 2. In a panel-

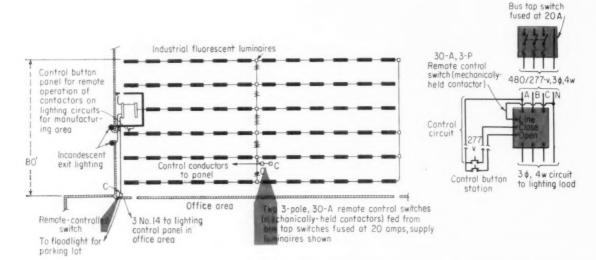


board, to control the main bus in the panel or only a section of the main bus; 3. In an enclosure, to control a small number of feeder circuits; 4. As a group in an enclosure with time switches which operate the coil circuits on a preset schedule; and 5. In a switchboard, to control feeder circuits which originate in the same enclosure.

#### REMOTE CONTROL OF LIGHTING

Magnetic contactors—remote control switches—are mounted on columns, near the ceiling, in this high bay industrial area. Lighting circuits for fluorescent netic switches down to a panel of control switches.

and carried through the column-mounted magnetic switches before connection to the luminaires. Control conductors are carried in conduit from the magnetic switches down to a panel of control switches.



pushbutton or toggle switch in the coil circuit. Or a set of auxiliary switch contacts can be used to keep current flowing in the coil circuit when a momentary pushbutton or switch is used. The coil supply circuit is generally tapped from the line side of the magnetic switch itself. The type of contactor in which the coil must be energized to keep the contacts closed is called a magnetically-held contactor.

A variation on the magneticallyheld contactor is the mechanicallyheld contactor, in which the operating coil is only momentarily energized to close the contacts and momentarily energized to open the contacts. During the time that the contacts are closed or open, the coil is not energized and the contactor is held closed by some mechanical means or by a permanent magnet. Because of the definite switch action-with mechanically maintained open and closed positions-such a contactor is commonly distinguished from the magnetically-held type by calling it a "remote switch.'

As the name implies, a remote switch offers operation of the contact assembly from one or more distant control stations. In such applications the switch is placed in the circuit which it is to switch. This may be in the middle of a splitbus panelboard where the switch controls one section of bus. It may

be adjacent to a panel, where the switch controls a branch circuit or feeder from the panel. Or it may be placed up on a column, where it switches lighting circuits for, say, an industrial area. Then in each case, control conductors are run in cable or conduit from the switch enclosure to one or more control points at which pilot devices provide for operation of the remote switch. The pilot devices may be momentary pushbuttons, toggle switches or an automatic device like a time switch. Layout of such contactor circuits is almost unlimited.

The mechanically-held contactor has certain application advantages over the magnetically-held type. For instance, it will not change its operating position-will not trip out-on voltage dips or failures, as magnetically-held contactors always do. For this reason, the mechanically-held type is better suited to use on circuits for lighting and other loads where conditions of voltage fluctuation, which do not hurt the load devices, would keep dropping out magnetically-held contactors. Of course, where voltage is stable, magnetically-held contactors will provide maintained, uninterrupted closure on circuits.

Magnetic switches offer many advantages in convenience and ready utilization for switching of ac and dc loads where frequent opening

and closing of the circuit is a requirement or where remote and/or automatic operation is desired. Typical magnetic switches are made in ratings up to 1000 amps, up to four poles, to 750 volts ac or dc. Some units are specially rated for the high inrush current conditions of switching tungsten filament lamps. Units are also rated for heating loads and fluorescent lighting loads. Up to the limit of their ability to break locked-rotor current, they can also be used for motor branch circuit switching where overload protection is provided elsewhere and for motor feeder switching.

Use of magnetic contactors to control large blocks of lighting can be made in many ways. One or more contactors may be mounted in the lighting panelboard to control lighting circuits or sections of the bus, or may be mounted in or out of the panel to control the entire panel. Such use of contactors can provide remote control of lighting supplied from panelboards in out-of-the-way places. Typical of such application would be the use of a contactor to control an entire lighting panel installed in the space above the ceiling of a convention hall or auditorium to supply the lighting for the main interior. In such a case, a mechanically held contactor would be installed either in the panel or just ahead of it, and its control circuit would be carried down to pilot switches at the floor level or other level at which a lighting control center might be located.

Another contactor application for full panel control might involve locating the contactor at widely spaced lighting panelboards supplying outdoor lighting with all of the control circuits brought to pilot switches at a common point of control. For control of individual circuits supplying lighting loads, contactors may be located near the panelboard or near the load with the control circuit arranged for maximum convenience. In all of these cases, the operating coil circuits of the contactors might be supplied in a number of ways depending on voltage, controlled by manual pilot switches or automatically by time switches.

Control circuits for magnetic switches may be energized at the same voltage as that of the switched supply or may be operated at a lower voltage obtained through a separate or built-in control transformer. The coil of corresponding voltage rating is then selected.

Control circuits may be either 2-wire or 3-wire depending upon the type of contactor and the type of pilot device. For magnetically-held contactors, only two wires are needed when the pilot control device is an automatic type-like a float switch, a pressure switch, a time switch or limit switch. Three wires are needed when a momentary contact pushbutton station is used in combination with a set of auxiliary holding contacts in the switch. Mechanically-held contactors use three control circuit wires-one for "OPEN," one for "CLOSE" and a common wire-to provide the definite switch actions.

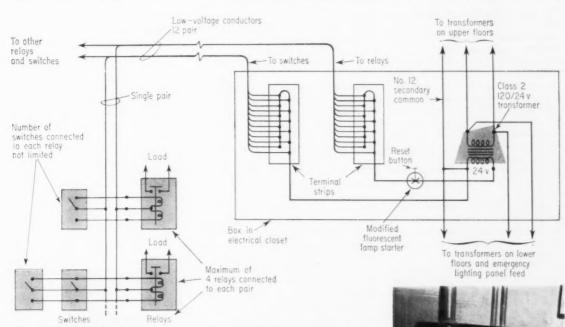
#### Relays

Relays are low-current, light duty magnetic contactors. Their load contacts are more often used to open and close control circuits than to operate power circuits. Both mechanically-held and magnetically-held types are made. Typical appli-

cations include control of contactor coil circuits, control of other relays, control of solenoids, and direct-current switching of circuits to lowcurrent motor and lighting loads. Selection criteria for relays are the same as those for a contactor.

In use, relays may be mounted in individual enclosures adjacent to load devices, panelboards or motor controls with which they are associated. Or they can be grouped on panels, open or in enclosures and mounted where space is available, where their operating noise is not objectionable and where their position provides the most efficient wiring layout for load and control circuits.

Common relays are rated for continuous current per pole at 10 or 25 amps, for switching of circuits up to 600 volts. Units are made with up to 12 poles, in various combinations of normally-open and normally-closed contacts with one or two throws of the contacts. Relay load contacts are rated for inductive and non-inductive loads, and some are rated in horsepower. Op-



**LOW-VOLTAGE SWITCHING** system in an office building derives low voltage from a transformer in a cabinet in the electric closet on each floor. The Class 2 remote control circuit wires are carried in conduit into the ceiling plenum, where the wires are then run open. Relays and switches tap off numbered pairs of wires. Modified fluorescent starter is used as a thermal CB to protect relays against sustained current due to accidental locking of the switches in the closed position.



**CONTROL RELAYS** and contactors for industrial plant motors are grouped in a large wall-mounted cabinet which is bolted to concrete block wall.

erating coils are available with a range of voltage ratings—6, 12, 24, 32, 64, 110, 220, 440, 550 and 600 volts.

#### Low Voltage Switching

Low-voltage relay switching of lighting equipment has become popular in residential and commercial occupancies. It is used where remote-control, multi-point control and/or frequent control is required for a number of small 120-volt or 277-volt lighting loads—individual luminaires or closely-mounted luminaires. The method offers reduced wiring requirements in many cases and eliminates need for line-voltage switches, reducing costs and adding safety.

Layout of low-voltage relay switching systems can be made in many ways, depending upon the relay components and the branch circuit conditions:

In some cases, all of the relays may be mounted in an enclosure near the panelboard supplying the branch circuits which the relays switch, with a single transformer mounted there to supply the low voltage. Where a single panelboard serves a large number of lighting branch circuits over a very large area-such as large office areas in commercial buildings, a number of relays associated with each section of the overall area may be group-mounted in an enclosure in that area. Or an individual relay may be mounted in an outlet box to

control a single fixture or a group of fixtures.

Another type of low-voltage relay system uses combination relay-transformer units which are mounted in outlet boxes to control single fixtures or groups of fixtures, with the transformer primary connected to the branch circuit conductors at the relay unit location and low-voltage control wiring carried down to the low-voltage switches for control.

#### Other Switches

A number of other types of smaller switches are used in modern electrical systems. These include:

General-Use Snap Switch-This is the common wiring device switch. It is so constructed that it can be installed in flush device boxes or on outlet box covers or otherwise used in conjunctoin with standard wiring systems. These are made in a wide variety of types and constructions. There are toggle types, single pushbutton types, rotary type, mercury switches with toggle handles and switches with special operating handle arrangements. Such switches are used in just about every type of interior wiring system to control branch circuit equipment-lighting units or appliances.

Standard flush tumbler switches with toggle handles are made in both spring-operated types and mercury types. Typical ratings are: 10amp, 125-volt or 5-amp, 250-volt; 20-amp, 125-volt or 250-volt; 30amp, 125-volt or 250-volt. These include single-pole and doublepole units, 3-way and 4-way switches and top-wired and sidewired screw terminal types and the push-in type terminals. And standard 15-amp and 20-amp switches are available with 277-volt rating for use on 480/277-volt lighting systems.

In addition to the standard line of switches, there is a line of smaller, light-duty units called interchangeable devices. In this line there are both receptacles and wiring switches. As many as three such switches can be used in a single switch box which can take only one standard line flush switch. In some cases, interchangeable switch units have the same ratings as the standard line units.

Automatic Switches-This cate-

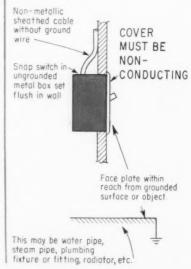
#### CODE RULES ON SNAP SWITCHES

1. Snap-switches used for incandescent lamp loads must be "T" rated or, on ac circuits, must be general-use ac snap switches. A switch that is not "T" rated and is not an ac snap switch may be used under certain conditions in residences and hospital and hotel rooms, but not in public places.

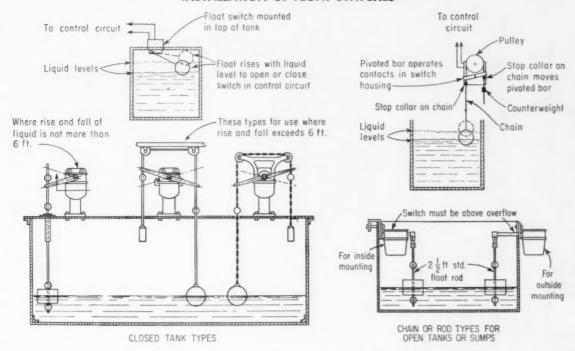
2. An ac general-use snap switch may be used to control incandescent and fluorescent lighting loads up to the ampere rating of the switch at the voltage involved (120 volts for incandescent loads). It may be used to control motor loads up to 80% of the ampere rating of the switch at the rated voltage.

3. An ac-dc general use "T"-rated snap switch may be used to control incandescent lighting up to the ampere rating of the switch at 125 volts. It may be used to control fluorescent lighting, motor loads or other inductive loads up to 50% of the ampere rating of the switch at the voltage involved.

4. Covers of flush snap switches which are mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces must be made of non-conducting, non-combustible material. This requirement conforms to the spirit of another code rule covering grounding of equipment near grounded surfaces: ungrounded metal faceplates shall not be installed in contact with conducting surfaces nor within 8 ft vertically or 5 ft horizontally of laundry tubs, bath tubs, shower baths, plumbing fixtures, steam pipes, radiators or other grounded surfaces.



#### INSTALLATION OF FLOAT SWITCHES



gory includes the various types of small switches in which operation of the contacts is performed by some impersonal action:

1. A commonly used pilot device to automatically control operation of motors associated with water or gas systems is the pressure switch. Such a switch is an assembly containing electrical contacts arranged to be opened or closed by mechanical action of a diaphragm or piston which is actuated by pressure of water, steam, air, gas, etc. Of course, the switch must be connected to a pipe or boiler or other vessel containing the medium which operates the switch, to permit the medium to act on the diaphragm. In any application, the switch is set to operate automatically at predetermined values of pressure or vacuum, making or breaking an electrical control circuit. Pressure switches contain means of adjusting the setting at which they will operate.

A range of pressure switches is made for automatically starting and stopping motors in water pump service and air compressor service, with or without hand disconnect levers for shutting off the circuit manually and with other modifications to suit different applications.

2. A float switch is a unit containing contacts actuated by a lever

arm which is moved by a chain or rod attached to a float riding up or down with the level of liquid in a tank. Such switches are used with motors operating pumps which control the level of liquid in tanks. Common applications for float switches include automatic control of motors operating sump pumps and tank pumps.

A number of different constructions and mounting types are available in float switches. Units are made with rod-attached floats or chain - over - pulley float arrangements to operate the internal switching assembly, with varying travels of floats. Several mountings are used for float switches for open tanks: through-the-top mounting provisions are made on float switches for closed tanks. Multicontact type float switches provide starting and stopping of a number of pumps in a predetermined sequence to obtain the required pumping capacity to maintain liquid level under varying conditions of level rise or fall.

3. A limit switch is another type of widely used pilot switch, in which contacts are made or broken in the coil circuit of a starter by travel or movement of the driven machinery. Limit switches are mounted in such a way that travel of the machine or the load it carries

will, at predetermined positions, trip the contacts within the switch housing. Limit switches are made in a very wide range of constructions for different applications. The actuating lever of lever-type limit switches may be a roller type, a push type, a fork type or a plunger type.

Typical applications of limit switches include: slowing down and stopping a motor at a desired point or limit of travel for the machine or load, initiating various control actions or sequences at definite points in the travel of a machine or load, and the interlock to provide starting or stopping of a motor or motors in response to the travel of a load driven by another motor. The simple lever-actuated limit switch is commonly called the "track type" limit switch. It may be mounted on the machine or load and tripped by coming into contact with some stationary object. Or it may be mounted stationary and tripped by movement of the machine or load.

4. A time switch is a pilot control or direct control device in which a clock-type timing mechanism is used to open and close contacts at pre-determined times. The timing mechanism in such a switch is an electrically driven clock—or may combine electric motor drive with spring drive.



### Overcurrent Protective Devices

N DESIGN of an electrical system, required current-carrying capacities are determined for the various circuits - feeders, subfeeders and branch circuits. Then these required capacities are converted into standard circuit conductors which have sufficient currentcarrying capacities based on: the size of the conductors, the type of insulation on the conductors, the ambient temperature at the place of installation, the number of conductors in each conduit, the type and continuity of load and judicious determination of spare capacity to meet future load growth. Or if busway, armored cable or other cable assemblies are to be used, similar

considerations go into selection of conductors with required currentcarrying capacities. In any case, then, the next step is to provide overcurrent protection for each and every circuit.

The basic requirements behind effective application of modern overcurrent devices are in the NE Code and include the following:

- 1. The overcurrent device for conductors or equipment must automatically open the circuit it protects if the current flowing in that circuit reaches a value which will cause an excessive or dangerous temperature in the conductor or conductor insulation.
  - 2. Specifically, the general rule is

#### -NEMA FUSE SPECS-

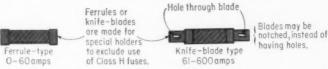
Class H low-voltage cartridge fuses are rated at 600 amps or less, 600 volts or less, ac and/or dc, for use in holders.

- A. Interrupting ratings range from 2,000 rms amps up to 200,000 rms amps.
- B. These may be current-limiting or non-current-limiting type fuses.
- C. In both single-element fuses and dual-element (time-delay type) fuses, the current classifications are: 0-30, 31-60, 61-100, 101-200, 201-400, 401-600 amps.
- D. Constructions are as follows, with specific dimensions for each current classification at 250 volts and each current classification at 600 volts, to make the classifications noninterchangeable with each other:



Class J low-voltage cartridge fuses are rated at 600 amps or less, 600 volts or less, ac only, for use in holders.

- A. Interrupting rating must be 200,000 rms amps.
- B. These are all current limiting type fuses.
- C. Current classifications are: 0-30, 31-60, 61-100, 101-200, 201-400, 401-600 amps.
- D. Constructions are as follows, with specific dimensions to designate each classification by current and voltage:



Note: Fuses are tested at a constant current on a 60-cycle circuit. They are tested in the open, mounted in a horizontal position—either in a single-pole fuseholder for fuses up to 600 amps or connected to bus bars for larger fuses. A fuse must be able to carry 110% of

that the device must be rated to protect conductors in accordance with their safe allowable currentcarrying capacities. Of course, there will be cases where standard ampere ratings and settings of overcurrent devices will not correspond with conductor capacities. In such cases, the next larger standard size of overcurrent device may be used. For instance a 3/0 type R, rated at 165 amps, may be protected by a standard 175-amp device. And where an adjustable-trip circuit breaker of the thermal trip, magnetic time-delay or instantaneous-trip type is used, it must be set to operate at not more than 125% of the current rating of the conductors it protects.

3. There are a number of exceptions to the rule that conductors be protected in accordance with their current-carrying capacities. These are made in the interest of practical application, where necessary for equipment operation, and where conditions of use provide substantial safety in the installation.

4. Overcurrent protection for conductors must also be rated for safe operation at the level of fault current obtainable at the point of their application. Every fuse and circuit breaker for short-circuit protection must be applied in such a way that the fault current produced by a bolted short circuit on its load terminals will not damage or destroy the device. Specifically this requires that a short-circuit overcurrent device have a proven interrupting capacity at least equal to the current which the electrical system can deliver into a short on its load terminals.

If a given short-circuit overcurrent device does not have sufficient interrupting capacity for its point of application, it must then be protected by another overcurrent device which does have sufficient IC to open the circuit on a load-terminal short on the given device. And this second device must have sufficient speed of operation to open the circuit before the given device can operate. In such hookups of dual over-

current protection, it is common to refer to the line side device as the protecting device and the unit nearer the load as the protected device.

Common application of dual protection uses combination units of molded-case circuit breakers with load side fuses. Such devices are used where the short-circuit duty exceeds that of the molded-case CB alone. The fuses have very high IC to meet the duty and have time-current characteristics to operate before the CB, in the range above the CBs IC. The CB provides overcurrent protection for operating overloads and ground fault and shortcircuit currents up to its IC, with the fuses opening the circuit only on overcurrent which exceeds the IC of the breaker. In this way, fullload switching is obtained with the protection against single-phasing and easy reset on low-level overloads which are characteristic of CBs, while complete protection is obtained from the fuses. And substantial saving is made over the alternative use of large air breakers with full IC rating.

Application of short-circuit overcurrent devices without careful determination of their suitability on the basis of IC can present serious hazard to life and property. Thermal and magnetic forces released in short-circuit interruption can cause explosion—with flying pieces and propagation of flame if the device is not designed, constructed and rated for the current it interrupts.

But safe application of a protective device does not stop with adequate interrupting capacity for its own use at the point of installation in the system. The speed of operation of the device must then be analyzed in relation to the thermal and magnetic energy which the device lets through to any fault on its load side.

A device may be able to break a given short-circuit current without damaging itself in the operation; but in the time it takes to open the faulted circuit, enough energy may get through to damage or destroy other equipment in series with the fault. This other equipment might be cable or busway or a switch or motor controller which simply cannot withstand the few cycles of short-circuit current which flows in the period of time between initiation of the fault and interruption of the current flow.

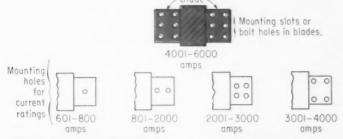
Class L low-voltage cartridge fuses are rated at 601-6000 amps, 600 volts or less, ac only, for fixed stud mounting.

A. Interrupting rating must be 200,000 rms amps.

B. These are current-limiting type fuses.

C. Current classifications are: 601-800, 801-1200, 1201-1600, 1601-2000, 2001-3000, 3001-4000, 4001-6000 amps.

D. Construction is as follows, with dimensions and mounting holes in terminal blades to designate ampere classification:



Class M low-voltage cartridge fuses are rated at 601-6000 amps, 600 volts or less, ac only, for fixed stud mounting.

A. Interrupting rating must be 200,000 rms amps.

B. These are not current-limiting type fuses.
 C. Current classifications are same as Class L fuses.

D. Construction is similar to Class L, but with different dimensions and mounting hole provisions for 2001-6000 amp sizes as follows:



its rated current indefinitely in this test. Because ratings are checked in the open, consideration must be given to effective derating of fuses when they are enclosed under conditions of heat accumulation.

#### OVERCURRENT DEVICE IN UNGROUNDED CONDUCTOR 4-wire 0000000 irounded 3-wire 1-phase 4-wire wye 3-wire PROTECTION IN GROUNDED CONDUCTORS Overcurrent device permitted Grounded in grounded conductor 3-wire when device opens all conductors of circuit at one time 3-pole Grounded 3-wire 3-phase Neutral not connected Keeeee in primary wye supply Three running overload units required to prevent damage to motor on single-phasing of 3-wire Branch circuit protection, but not primary wye in grounded conductor Controller Third unit in grounded conductor OVERCURRENT PROTECTION AT POINT OF SUPPLY Overcurrent devices where conductors are supplied from mains Branch circuit conductors are Feeder protected at conductors their carrying capacities cuits tapped protected at from panel mains point of supply Smaller conductors Feeder conductors tapping feede LOCATION OF SERVICE OVERCURRENT PROTECTION

Service overcurrent device integral part of disconnect

or adjacent to it

#### Code Rules On Over-

1. An overcurrent device (fuse or CB trip unit) must be placed in each ungrounded conductor of the circuit to be protected.

2. An overcurrent device must not be placed in any permanently grounded conductor, except: 1. where the device simultaneously opens all conductors of the circuit, or 2. where the device is used for motor running overload protection and is required by note to Table 430-37 for the grounded conductor of a 3-phase, 3-wire circuit from a delta supply with a corner grounded.

- Overcurrent devices must be located where the conductor to be protected receives its supply, except:
  - A. Overcurrent protection for service conductors must be an integral part of or located immediately adjacent to the service disconnect means at the load end of the service conductors, as near as possible to the point of entry of the conductors, either inside or outside the building. Or, the overcurrent device may be on the outer end of the entrance, ahead of the disconnect means.

Outside

Service-

conductors

Unusual case of service

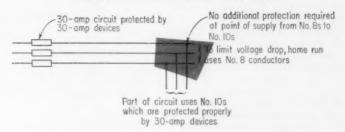
overcurrent protection, at point of supply from

Service disconnect

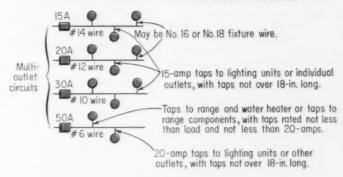
#### **Current Protection**

- B. Where the device protecting supply conductors is of rating or setting to provide protection for smaller conductors tapped from the larger conductors.
- C. Branch circuit taps—as covered in 210-19 and 210-20 are considered protected by the branch circuit overcurrent devices.
- D. Tap conductors from a feeder may be run 10 ft without protecting reduced size of the conductors if they have carrying capacity of not less than the sum of the capacities of the conductors for the circuits or loads supplied, if they do not extend beyond the device or devices they supply and if they are enclosed in conduit, EMT or gutters for the length of their run when not part of a switchboard or panelboard.
- E. Tap conductors from a feeder may be run 25 ft without protecting reduced size of the conductors if they have carrying capacity of not less than one-third that of the conductors which they tap, if the tap conductors are protected from physical damage and if they are terminated in a single CB or set of fuses which will protect the conductors not in excess of their rating.
- 4. Overcurrent devices must be located so they are accessible, excepting: service overcurrent devices, which may be at the outer end of the service; and overcurrent devices for circuits tapped from feeder busway, which may be in the device for tapping the busway, in the cord plug of a fixed or semi-fixed luminaire supplied from trolley busway, or mounted on a luminaire plugged into a busway.

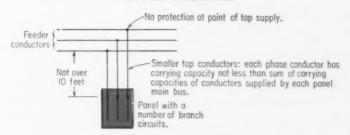
#### PROTECTING TWO SIZES OF CONDUCTORS



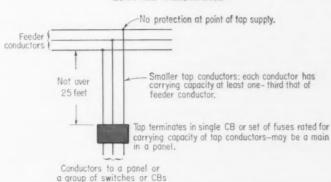
#### TAPS PROTECTED BY BRANCH CIRCUIT DEVICES



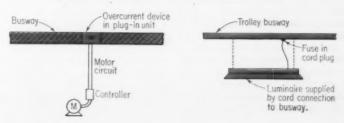
#### 10-FT TAP ALLOWANCE



#### 25-FT TAP ALLOWANCE



#### INACCESSIBLE OVERCURRENT DEVICES - PERMITTED



All protective devices take some time to operate. The shorter this time, in any case, the lower will be the destructive thermal and magnetic forces acting on the circuit conductors and equipment. In general, fuses are faster acting devices than circuit breakers, due to the inertia of mechanical operation in a CB. However, both fuses and CBs can be effectively applied to assure safe correlation between letthrough energy and destruction-resistance of circuit components.

5. Coordination is the time-current relationship among a number of overcurrent devices connected in series-such as main feeder, subfeeder and branch circuit overcurrent devices. Although safety is the prime requirement in the operation of short-circuit overcurrent devices, coordination of overcurrent devices has become an extremely important consideration in the large and complex electrical systems used in modern industrial, commercial and institutional buildings. In fact, lack of attention to the matter of coordination is the most common shortcoming in many otherwise well-designed electrical systems.

A given system may have each and every short-circuit overcurrent device properly rated for continuous current and overload and fully rated for IC at its point of application; but a feeder fault may be cleared by the service main overcurrent device, or a branch circuit short will operate a feeder fuse before the branch circuit CB opens. In such cases, service interruption in the system is much more widespread than it would be if only the device nearest the fault operated. Effective coordination, therefore, can minimize the extent of outages with their consequent disadvantagesloss of production, interruption of critical continuous processes, loss of vital facilities in a hospital, possibility of panic on lighting failure in public places, etc.

Coordination of overcurrent devices can be made on the basis of one of a number of schemes which correlate safety and minimum fault outages with economic factors:

Selective Coordination—This plan of overcurrent protection provides for clearing any short-circuit or ground faults by the device nearest to the fault on the line side. A fault on a branch circuit is cleared by the branch circuit overcurrent device; and the subfeeder, feeder and main overcurrent devices in series with

#### CODE RULES ON FUSE APPLICATION

1. Standard ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000. Fuses with ampere rating other than the standard rating listed may be used when they are of lower ampere rating than the standard fuse which could be used.

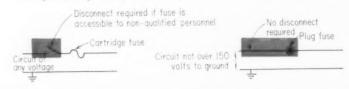
#### USE OF PLUG FUSES

2. Plug fuses must not be used in circuits of more than 125 volts between conductors, but they may be used in grounded neutral systems where the circuits have more than 125 volts between ungrounded conductors but not more than 150 volts between any ungrounded conductor and ground. And the screw-shell of plug fuseholders must be connected to the load side of the circuit.



#### **FUSE DISCONNECTS**

3. Disconnecting means must be provided on the supply side of all fuses in circuits of more than 150 volts to ground and cartridge fuses in circuits of any voltage, where accessible to other than qualified personnel.



the branch device back toward the service entrance will not operate. On a subfeeder fault, only the subfeeder device will open. Only the faulted part of the system is taken out of service—which represents the minimum outage. On the other hand, a branch circuit fault which takes out the protective device for the subfeeder or feeder supplying the branch circuit panel, causes loss of power to all panelboards fed by the subfeeder or feeder.

Each protective device in this plan is rated for short-circuit duty at its point of application. The coordination is achieved by studying the curve of overload current vs time required for operation of each device. Then selection of devices is made so that the device nearest the load is faster operating than all the devices behind it; and each of the

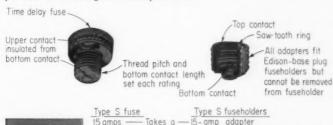
other devices going back to the service entrance is faster operating than any of the devices behind it. The main overcurrent device, the one farthest from the load must have the longest time delay on branch circuit faults.

Cascade Coordination — In this plan, large air CBs (low-voltage power breakers) can be used at points of application where the short-circuit duty exceeds the IC of the breaker. This is possible when the device is backed up by a fully rated power breaker which will operate with the smaller device on a fault on the load side of the smaller breaker. This is an economy type application for use only with large air CBs.

In the cascade plan, a feeder CB will not have sufficient IC for its point of application. The main CB

#### TYPE S PROTECTION RESISTS TAMPERING

4. Effective January 1, 1961, fuseholders for Edison-base plug fuses must be Type S to accommodate Type S plug fuses. Fuseholders must be designed or equipped with adapters to take either a 0 to 15-amp Type S fuse or a 16- to 30-amp Type S fuse; and 0 to 15-amp fuseholders or adapters must not be able to take 16- to 30-amp fuses. The purpose of this new rule is to prevent overfusing of 15-amp circuits.



FOR CIRCUIT PROTECTION	20 amps — Takes a — 25 amps — Takes a — 30 amps — Takes a —	
CIRCUIT	0.3 -1 amp 1.12 - 1.25 amps 1.4 - 1.6 amps	Range of corresponding adapters provides tamper-proof protection in variety of current ratings up to 14

12 - 14 amps -

5. Standard cartridge fuses and fuseholders are divided into distinct ampere classifications as follows:

A. Rated not over 250 volts: 0-30, 31-60, 61-100, 101-200, 201-400, 401-600.

amps.

B. Rated not over 600 volts: Same classification as the foregoing, plus 601-1200, 1201-1600, 1601-2000, 2001-3000, 3001-4000, 4001-6000.
Fuses rated for 600 volts may be used at any lower voltage.

 Cartridge fuses and fuseholders must be such that a fuse of any given class cannot be used in a fuseholder of a lower current or higher voltage rating than the fuse class.

7. Fuseholders for current-limiting fuses must not permit insertion of fuses which are not current-limiting.

supplying the feeders does have sufficient IC for its point of application. Both devices are equipped with instantaneous trips. The instantaneous trip device in the main CB is set to operate at some current value just under the IC rating of the feeder CB. Thus, on shorts above the rating of the feeder CB, both CBs will open to effect current interruption, although there may be damage to the feeder CB.

Cascade coordination, therefore, can cause extensive outages and require more maintenance. Its use should be justified only by skillful engineering analysis of all elements involved.

Partial Coordination—In this plan, each protective device is rated to satisfy short-circuit duty at its point of application, but instantaneous trip characteristics are used instead of selectively calibrated time-delay trips. With such usage, two series protective devices may operate together when they are close together and the fault current reaches the level of the instantaneous trip setting of the two devices. However, in many cases, the impedance of cable run from a feeder device to a subfeeder device will reduce the level of fault current on the load side of the subfeeder device to a value below the instantaneous setting of the feeder device. Thus some measure of selective coordination is obtained.

Of the three coordination plans, the selective type is fast becoming the most desirable and most popular type. The cascade type and fullyrated partial coordination types represent levels of lower cost and lower system continuity.

#### Fuses

Modern fuses offer well-engineered effective circuit protection at relatively low cost. There are types and sizes of fuses suited to the wide range requirements of today's electrical systems. Selection and installation of fuse protection involves a number of considerations, as follows:

1. Where interrupting duty on a protective device is in the range from 100,000 to 200,000 rms symmetrical amperes (or higher), fuses will almost always be required. In some cases, they will be the only suitable devices for the job. In other cases, their economy will far outweigh any advantages of an alternative CB. And the use of current-limiting fuses reduces the required short-circuit rating of load side equipment-switchboards and motor control centers can be braced for lower current levels. High-IC application may be made with a bolted pressure contact switch, an interruptor switch or general-use switch or may be made in combination with a CB. In the latter case. the two devices are coordinated so the fuses operate on only the high short-circuit currents - covering the required range above the capacity of the CB to interrupt current. All the advantages of CB protection and control are, therefore, available from load current up to low-level shorts which the CB is capable of clearing.

2. Fuses are fast-operating devices. Selective coordination requires careful study where fuses are used in the main, feeder, subfeeder and branch circuit levels of a system. Fuses of the same type—same operating characteristic—can provide coordination on the basis of size: on a given short-circuit current, the fuse with the lowest continuous current rating will open before any other similar type fuse of higher rating in the fault circuit.

Speed of fuse operation, however, makes it difficult to coordinate fuses with a CB on its load side. The opposite, however—a CB with fuses on the load side—offers very effective coordination, with the fuse operating before the CB for faults on the load side of the fuse.

Fuse manufacturers make available coordination data on the use of their fuses. Such data include the ratios of sizes in which particular types of fuses will operate be-

#### MOUNTING FUSES IN FUSEHOLDERS

Solid, low-resistance connections must be assured for all joints in any fuse installation. High-resistance contact will cause objectionable heating, reducing the continuous full loading of the fuse, causing blowing of the fuse and often damaging the switch, panelboard or other device in which the fuse is used. Careful attention must always be paid to the task of installing fuses:

1. Spring-type fuse clips should make tight contact with fuse terminals over a large area of fuse terminal—whether a ferrule or knife-blade. Damaged clips must not be used. Avoid the following types of contact between fuse and fuseholder:



Ferrule-type

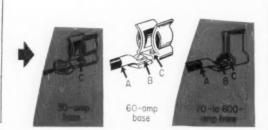


2. All joints in the conductor connection to the fuseholder must have sufficient area of contact and sufficient pressure to assure a low resistance current path.

Lug "A" must be properly fastened to the wire or cable.

Bolt "B" holding lug to fuseholder post must be tightly drawn up.

Screw "C" holding clip to fuseholder base must hold clip tight.



#### NON-INTERCHANGEABILITY

Some Class J low-voltage cartridge fuses—up to 600 amps, current-limiting type—have special ferrules or knife blades to provide installation in conformity with NEC Section 240-23 (b); fuseholders for current-limiting fuses must not permit insertion of fuses which are not current-limiting. Such fuses can fit into current-limiting fuseholders and may also fit standard NEC fuseholders. But standard NEC fuses (Class H) cannot be inserted into the current-limiting holders.

Notches permit installation in fuse clips with bolt through each-for fuses from 61-600-amps.

Close-up of one fuse clip for current-limiting fuse with notched blade.



Bolt passes through the clip, excluding use of any fuse blade without not Standard blade w

blade without notch. Standard blade would hit the bolt and could not be inserted



Ferrules are designed for either standard NEC clips or for special rejection clips which take only the current limiting type fuse.

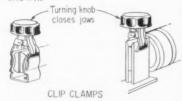
#### INSERTING FUSES

1. Do not insert a fuse on a live circuit. Doing so causes an arc which will gouge the ferrule or knife-blade and reduce effective contact in the holder.

Fuse clips and ferrules and blades must be thoroughly clean and smooth across contact surfaces. Use emery cloth where necessary to clean contacting parts.

3. A ferrule in its clip is not easily rotated if contact is tight and sure. A knife blade is not readily inserted into spring clips without good pressure if the clip has proper pressure.

4. Any spring-clip which has lost its gripping pressure should be replaced or equipped with clip clamps of the proper size to produce tight connection between fuseholder and fuse terminal, as shown.



fore larger fuses of the same or different operating characteristics. And for use of fuses ahead of circuit breakers, comparisons of opening times are available for selective coordination. Use of such data assures that the CB opening time is less than the melting time of the fuse at the fault current level available at the CB.

3. Use of fuses may or may not require the use of a switching device in conjunction with the fuses. The NE Code requires that a disconnecting means be provided on the supply side of all fuses in circuits of more than 150 volts to ground and cartridge fuses in circuits of any voltage where such fuses would be accessible to other



**LIYE-FRONT SWITCHBCARD** uses bolted-in 600-volt current-limiting fuses rated over 600 amps. Open mounting produces good ventilation for fuses allowing heavier loading and cooler overall operation of switchboard.

#### TYPES OF FUSE REDUCERS

Fuse reducers are fuse terminal adapters which make possible the use of given sizes of fuses in fuseholders of higher current classifications. A typical application of fuse reducers is in the use of time-delay fuses in switches with fuseholders sized for larger fuses, for motor branch circuit protection and disconnect. (NEC Sections 430-52, 430-56).





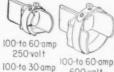


30-amp 250-volt

Reducers slide on fuse caps.

#### FERRULE-TO-FERRULE





250-volt

600-volt 600-volt

Reducers slide on fuse caps. Reducer blades are then lined up so clips will not be sprung

#### KNIFE-BLADE-TO-FERRULE



200-to 100-amp 400-to 200-amp -600-to 400-amp 250-or 600-volt



400-to 100-amp 600-to 100-amp -600-to 200-amp 250-or 600-volt

Reducers slide on fuse blades. Screw-on reducer clamp is then tightened to assure good contact

#### KNIFE-BLADE-TO-KNIFE-BLADE

than qualified persons. Required disconnect must be provided for each circuit containing fuses. A main disconnect for a number of fused circuits is permitted only for a group of fused motor circuits. Of course, switch control or disconnect of any circuit may be required for convenience or for some specific design reason-even where the code does not require a switch.

4. Fuses are thermal devices. They are therefore affected by ambient temperature which can alter their calibration. And the thermal characteristic of fuses produces a more or less common time-current operating curve, limiting the coordination possibilities.

5. Fuses do not have adjustable

operating characteristics to meet changes in size or nature of loading. Change in time-current characteristic is made by changing to another type and/or size of fuse.

6. Fuses for branch circuit protection present the possibility of single-phasing on polyphase systems with the consequent possibility of damage to motors. Effective application of motor running overload protection can eliminate any danger in systems where there is no transformer between the fuses and the motor. In fact, time-delay fuses for the branch circuit protection may be sized to provide motor running overload protection. And where primary single-phasing in delta-wye or wye-delta transformer circuits presents a hazard to motors even with running overload protection, the use of time-delay fuses for branch circuit protection in the secondary circuit to the motor will permit reduction in fuse size to provide protection against singlephasing. There are, however, code approved motor hookups in which single-phasing can cause motor burnouts.

# pinininini

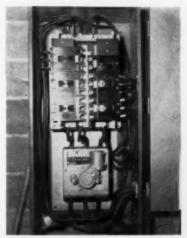
CB-FUSE UNITS, each consisting of a 225-amp molded-case CB with built-in current-limiting fuses, are mounted in this enclosure on a 4000-amp busway riser in a large office skyscraper. Each CB unit is attached to the busway by bus straps tied into the busway. The CBs are connected to the straps. The combination units feed distribution panels.

#### **Circuit Breakers**

A circuit breaker is a device for interrupting current flow in a circuit under normal or abnormal conditions. Up to its continuous current rating a circuit breaker is simply a switching device. Above that rating-on either light overload or heavy short-circuit current -a circuit breaker is an automatic overcurrent protective device. Its functions, therefore, correspond basically to that of a switch in combination with fuses. Modern engineered selection and application of circuit breakers depend upon a clear understanding of the characteristics of available types of circuit breakers and their accessory de-

A molded-case circuit breaker is a circuit breaker mechanism assembled as a complete switching and overcurrent protective device in a supporting and enclosing housing of insulating material. For modern circuit applications, such units are made in sizes from 15 amps up to 800 amps, with one, two or three poles, for circuits rated up to 600 volts.

Molded-case CBs are divided into size groups on the basis of frame sizes. A given frame size embraces a range of ratings of CBs which



MAIN CB in industrial subfeeder panel is equipped with motor-drive operator for remote control and resetting of the CB from a distant control point. The CB can also be operated manually by use of a handle.

have the same size molded case. The cases of a given frame size are, therefore, physically interchangeable. The frame size is designated by referring to the largest ampere rating available in that group, e.g., 100-amp, 225-amp, 400-

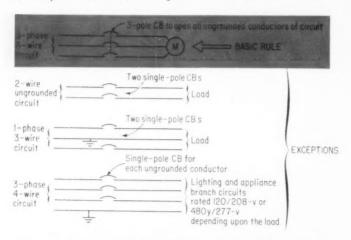
Short-circuit interrupting capacities of molded-case circuit breakers vary with frame size and with volt-

#### CODE RULES ON CIRCUIT BREAKERS

1. Standard ampere ratings for non-adjustable trip CBs are 15, 20, 30, 40, 50, 60, 70, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 500, 600, 700, and 800.

#### CBs MUST OPEN ALL UNGROUNDED CONDUCTORS

2. Circuit breakers shall open simultaneously all ungrounded conductors of circuits they protect, except that individual single-pole CBs may be used for protection of each ungrounded conductor of certain types of circuits, including ungrounded 2-wire circuits, 3-wire single-phase circuits or lighting or appliance branch circuits connected to 4-wire, 3-phase systems provided such lighting or appliance circuits are supplied from a grounded neutral system and circuit voltages conform to Section 210-6.



- 3. Handles or levers of CBs and similar parts which may move suddenly in such a way that persons in the vicinity are liable to be injured by being struck by them shall be guarded or isolated.
- 4. CBs shall be arranged and mounted so that their operation is not likely to injure the operator.

#### NON-INTERCHANGEABLE BRANCH CBs

5. CBs used for lighting and appliance branch circuits in residential and other occupancies—except where maintenance and supervision assure that overcurrent protective devices will be maintained at proper rating—must be non-interchangeable among the following three classifications of breakers rated not more than 100 amps, not over 250 volts ac:

0-20 amps 21-50 amps 51-100 amps

	7	Philippin stages I		
Circuit /		20	20	
breaker	18 8	20	20	
anelboard )		20	20	
not under )	3	20	20	
qualified (	12	30	50	1
pervision \	5	30	50	
	3743	00	and the second	

These 20-amp CBs for lighting and appliance circuits cannot be replaced by 30-amp or larger CBs.
These CBs cannot be replaced by any CBs over 50-amp rating.

Note: This code requirement becomes effective July 1, 1960.

age rating. The Underwriters' Laboratories tests for 5000 amps IC in CBs up to 100-amp continuous current rating and for 10,000 amps IC on any CB rated over 100 amps or any CB at any current rat-

ing when the unit is rated over 250 volts. NEMA assigns its own set of required IC ratings, and the manufacturers provide their own ratings for specific types and sizes of units. Molded-case CBs may



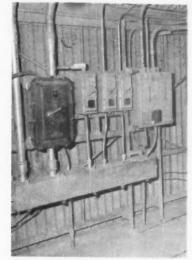
**TWO-POLE CBs** are used for feeder protection and disconnect in lower sections of this special control panel assembly for a 600-volt, 6-wire, 840-cycle distribution system for lighting in an office building. Upper part of switchboard contains control equipment for operation of 840-cycle M-G sets.

have ICs up to 75,000 rms amperes by themselves and over 200,000 rms amperes when current-limiting fuses are used in conjunction with the CB unit.

Molded-case CBs may have thermal-magnetic or fully-magnetic trip operation. In the first type, overloads up to about ten times the continuous rating of the unit will be opened by a heat-responsive mechanism, with a time-delay characteristic inversely related to the amount of overload. Higher current values will actuate the magnetic short-circuit trip mechanism to open the circuit instantaneously. In a typical fully-magnetic CB, time-delay operation on overloads up to ten times current rating is provided by a magnetic coil working with a movable core in an oil dashpot. Again time-delay is inversely related to current. At higher currents the magnetic trip assembly is capable of opening the circuit without movement of the core slug.

Some molded-case CBs—in the range of sizes up to 100 amps—have non-interchangeable trip mechanisms of fixed operating characteristics. Others—in the larger sizes—have adjustable short-circuit trip elements which may also be interchangeable. And there is a type of molded-case CB in the larger sizes which contains only a short-circuit trip element and has no time-delay overload trip to cover the range up

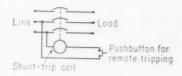




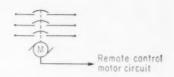
**DUST-TIGHT ENCLOSURES** for CBs in a conveyor tunnel of a grain elevator are dust-ignition-proof equipment approved for Class II, Group G installations. Equipment is bolted to angle-iron frame and fed from a dust-tight gutter with a gasketed cover and flange-type bolted cover locks.

to the short-circuit trip setting. Such a CB is designed for use in combination with motor starters, where the running overload device in the starter will take care of overloads and the CB will operate only on high level faults above the capability of the running overload device to clear the circuit.

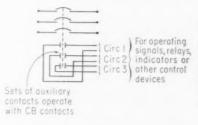
In the smaller sizes (15-100 amps) of molded-case CBs, those for panelboards and so-called load centers for residential and lightduty commercial use, there are many types of units suited to varying conditions of use. For application where the CB units will not be used for frequent switch control of the circuit and where IC is less than 5000 amps, there are single- and multi-pole units which offer excellent overcurrent protection with simple reset after trips. Some such units trip to the "OFF" position; others have trip-indicating positions for the handles. This latter feature provides instant identification of tripped circuits in a panel where a number of circuits might be normally "ON" and a number normally "OFF." Where switch control is required at the panel CB, units with quick-make, quick-break contact operation offer longer, more reliable life. And where required by voltage or where IC exceeds 5000 amps, E-frame CBs can be used up to 10,000 amps or F-frame CBs up to 20,000 amps.



SHUNT TRIP: Opens breaker by remote control, permits pushbutton remote tripping. Used to disconnect power from a remote or centralized point or to interlock with other electrical circuits (ac or dc). Can be actuated by limit switch or relay for automatic feedback control.



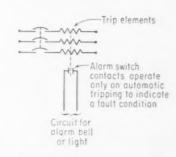
MOTOR-OPERATED MECHAN-ISM: Opens, closes and resets breaker by remote control. Can be used for automatic reclosing or preferred-emergency hook-up by addition of relay. For automated installations, isolated unattended pumping stations, radar systems, etc.



AUXILIARY SWITCH: Operates relay and control circuits at same time as breaker. For remote indication of breaker position (ON or OFF) by means of indicating lights. Can also actuate relays, control related equipment, interlock with other breakers.

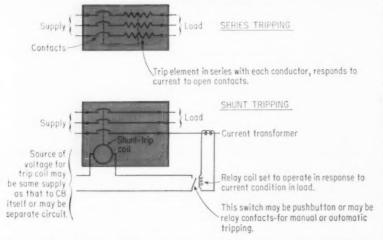


UNDERVOLTAGE RELEASE: Trips instantly when voltage dips. Used to protect motors, elevators, hospital and theatre lights against damage or loss of voltage and to actuate emergency equipment. Voltage must be restored before breaker can be reclosed. No time delay in operation.



**BELL ALARM SWITCH:** Signals when breaker trips, protects against unobserved outage, resets automatically.

#### TYPES OF CB TRIP OPERATION



NOTE: The series-trip element is a direct-acting, automatic circuit-opening device. The shunt-trip coil does not act directly in the load circuit. Through relays, shunt-trip coils may be used for automatic overlaad opening of the load circuit or may be used with a manual switch in the coil circuit for manual tripping of the CB. Relay-type overcurrent protection with circuit breakers or contactors varies widely in characteristics and application, constituting a considerable engineering task in effective selection.

#### Power CBs

Low-voltage power circuit breakers, also called large air breakers, are heavy-duty switching and protective devices with high interrupting capacities. Such CBs have rugged contact assemblies, provisions for arc suppression, either manual or electrically-powered operation. They are available either as individually mounted units—in wall or floor mounting enclosures—or in switchboards or load center substations. Typical characteristics of low-voltage power breakers are as follows:

- 1. Available in ratings from 15 amps up to 4000 amps, continuous current, in ratings of 240, 480 and 600 volts.
- 2. Interrupting ratings vary with size and voltage rating from 15,000 up to 150,000 rms amps asymmetrical (and beyond 200,000 amps in combination with suitable current-limiting fuses).
- 3. Fully-magnetic tripping characteristics based on as many as three individual elements—long time-delay, short time delay and-instantaneous trip. These separate elements may be used singly or in any combination to accomplish

time-current curve shaping for any selective coordination scheme. Adjustments are provided for the long and short time-delay pickup settings. The instantaneous trip may be set at the factory or may be adjustable.

Low-voltage power circuit breakers are used commonly for main and feeder disconnect and protection in large capacity secondary systems. They provide for circuit breaker application above the range of moldedcase CBs (800 amps). They are suited to applications where high frequency of switching operation demands a rugged unit to handle heavy currents. In combination with current-limiting fuses, they constitute high capacity service main devices for connection to secondary networks with extremely high short-circuit capabilities.

Application of all circuit breakers should include consideration of the following:

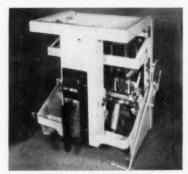
- 1. Practical elimination of singlephasing is effected through the use of multi-pole CBs on polyphase circuits.
- 2. Effective switching is provided for current interruption up to short-circuit rating and a CB can be safely closed against shorts.
- 3. Wide-range tripping adjustability facilitates selective coordination.
- 4. Some current derating should be used to cover effect of ambient temperature on thermal elements.
- 5. Speed of circuit breaker operation on overloads and shorts should be determined to evaluate danger of let-through energy. Current-limiting fuses are frequently the only solution.

#### MOUNTING POWER CBs: STATIONARY vs DRAWOUT

Low-voltage power circuit breakers—so-called large air breakers—can be mounted either stationary or with drawout construction. In the stationary type, the CB is bolted to the switch-board bus and secured to the structure. In the drawout type, the CB assembly is mounted on a simple racking mechanism which permits easy disconnecting of the CB and withdrawal from the enclosure.

Drawout-type CBs afford easier and safer maintenance. And because the weight of the CBs can be withdrawn, handling and installation of the switchboard enclosure is greatly simplified. Ready insertion of spare breakers during maintenance of regular units offers needed service continuity in many applications. Modification of breakers—change in trip elements to meet varying load requirements—is another advantage of drawout mounting.

Stationary-type CB mounting first of all reduces the depth requirement on the switchboard. And because CBs will not be drawn out, aisle space in front of the enclosure can be less than it would be with drawout CBs. The stationary-type is suited to minimum space applications.



TYPICAL CONSTRUCTION of manual 1600-amp low-voltage power circuit breaker shows its substantial frame and operating assembly. Such units meet all CB needs above 800 amps and find use even at lower current values where interrupting ability is beyond that of a molded-case CB. Unit may be mounted stationary or on drawout mechanism.

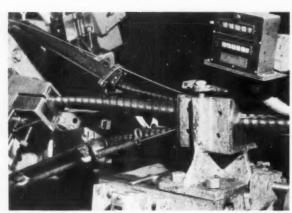
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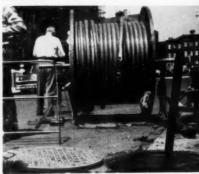
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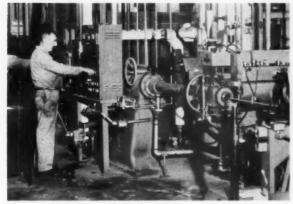
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# Uss Tiger Brand—here's why!

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The differences in electrical cable are seldom visible at a glance. They show up, for example, in mining machine cable that absorbs shock and vibration, withstands crushing weights, and severe abrasion for unbelievably long periods. Or they appear in a new irradiated polyethylene cable designed for extra-high resistance to heat and moisture . . . in submarine cables that work under water for 30 or 40 years . . . in power cables that resist corona cutting.

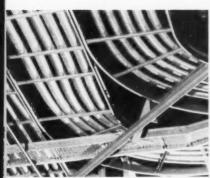
In USS Tiger Brand Cables, you reap the advantages of all the research, engineering skill and manufacturing experience gained in making every type of cable from the smallest control cable to the largest dredge cable. There is a difference in cable—and you'll find it by using Tiger Brand.



Modern Production Equipment. This new and up-to-date continuous vulcanizer is just one of the many new pieces of precision equipment that result in uniform high quality of USS Tiger Brand Electrical Cables.



**Field Engineering.** Where specific problems are encountered, our field service engineers are available to help you choose the right cable for the job or to suggest different constructions to obtain better service.



For industrial plants. Armorlokt armored cables eliminate conduit, reduce installation costs.

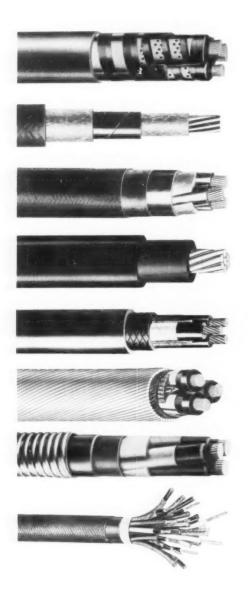


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Tiger Brand Varnished Cambric Cable—Furnished in braided coverings (for dry installations), lead sheaths (for underground distribution), or armored coverings (for exposed work). Versatile, dependable, rugged, and economical "work horse" of standard insulations.

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Tiger Brand Amerclad—The very highest quality in heavy-duty portable cords and cables. All jackets are vulcanized in a lead sheath, and are permanently marked with molded identifications. Over-all neoprene jackets show phenomenal resistance to abuse, sunlight, grease, oil or acid mine water.

Tiger Brand Submarine Cable—Special marine insulation, used on leadless armored cables, has over 40 years of proven operation in all types of underwater service. American Steel & Wire pioneered the use of aluminum armor for salt water installation.

Tiger Brand Interlocked Armor Cable — Aluminum, bronze, galvanized or stainless steel armor furnished over any type of insulated core. Features higher current carrying capacity (cable in free air), ease of installation and maintenance, and space saving. Rubber or varnished cambric insulations are standard.

Tiger Brand Elevator Cable—Carefully designed to insure the right amount of flexibility for smooth, straight trailing. Annunciator, control, signal, or lighting cables with braid or neoprene covers can be furnished, with steel supporting strand added for high-rise elevators.

For more detailed information, get in touch with American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.





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### Switchboards and Panelboards

AJOR National Electrical Code requirements, which apply to switchboards and panelboards, are summarized as follows:

Since switchboards and panel-boards contain overcurrent devices, Section 240-16 has a definite bearing on the ultimate location of such equipment. This section requires that overcurrent devices must be readily accessible (except as provided in Section 230-91 for service equipment and Section 364-11 for busways), not exposed to physical damage, or not in the vicinity of easily ignitible material.

Section 384-3 (a and b) requires that conductors and busbars on a switchboard, panelboard or control boards be so located as to be free of physical damage, and they must be held firmly in place.

Busbars and conductors must be arranged to avoid overheating due to inductive effect. Inductive effect can be avoided if all conductors of a circuit follow the same path through any opening in steel partitions within switchboard or panel-board enclosures.

Section 384-4 requires that switchboards with any exposed live parts be located in permanently dry areas and under competent supervision. Only qualified persons shall have access to switchboards with exposed live parts.

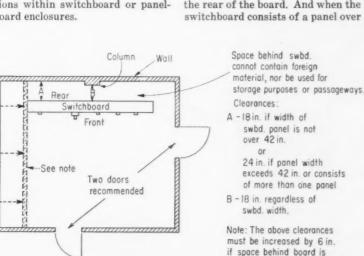
Section 384-5 requires weatherproof enclosures for switchboards installed in a wet location or outside of a building.

Section 384-6 requires that switchboards be so placed as to minimize the probability of communicating fire to adjacent easily ignitible material.

Section 384-7 requires a 3-ft minimum clearance between the top of a switchboard and a non-fire-proof ceiling, unless an adequate fireproof shield is provided between the board and the ceiling.

Section 384-8. If a single panel switchboard is not over 42 in. wide, and equipment or wiring is accessible only from the space behind the board, at least 18 in. of clear space is required between the wall and the rear of the board. And when the switchboard consists of a panel over

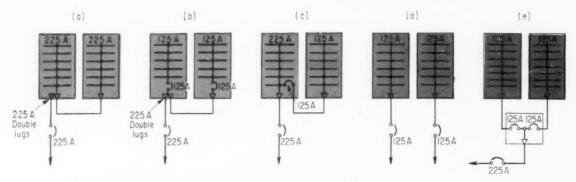
accessible only from one end.



Clearances for Switchboards Requiring Accessibility of Parts From Rear of Board

**SKETCH SHOWS** a typical switchboard room with minimum code clearances. As a safety precaution, two doors are recommended where switchboards are connected to systems having high current-interrupting capacities.





Note: These drawings apply only to lighting and appliance branch cct, panelboards.

FIVE DIFFERENT METHODS of connecting lighting and appliance branch circuit panelboards are possible when the rating of the feeder overcurrent device exceeds 200 amps. Also, any one of these methods may be used if more than 42

lighting and appliance branch circuits are required at the same location. In (a) and (b) a pull box or gutter can be substituted for double lugs shown in sketch. In (d) separate 125-amp feeders are used in lieu of a single 225-amp feeder.

42 in. wide or more than one panel, the clear space behind the board shall be increased to 24 in. If the space behind the board is accessible only from one end, these clearances shall be increased by at least 6 in. The space back of switchboards shall be kept clear of foreign material and shall not be used for storage purposes, nor as passageways.

Reduction of clearances for short intervals by building columns behind the switchboard, or by equipment on a single panel in the switchboard, is permitted provided the clearances are not reduced below those required for a single panel switchboard. Some of the previous dimensions are exceptions to Section 110-16.

Section 384-9. Conductor Covering. Insulated conductors where closely grouped, as on the rear of switchboards, shall each have a flame-retardant outer covering. The conductor covering shall be stripped back a sufficient distance from the terminals so as to not make contact with them. Insulated conductors used for instrument and control wiring on the back of switchboards shall be flame-retardant, either inherently or by means of an outer covering, such as one of the following types: R, RH, RW, RHH, RHW, V, AVA, AVB, T, TA, TBS, TW, THW, MI, or other types specifically approved for the purpose.

Section 384-11. Grounding Switchboard Frames. Switchboard frames and structures supporting switching equipment shall be grounded, except that frames of direct-current single-polarity switchboards need not be grounded if

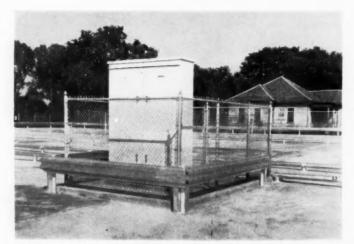
effectively insulated. Common practice is to place an insulated mat, such as rubber, on the floor in front of all switchboards where the floor is of conductive material.

Section 384-15 does not permit more than 42 overcurrent devices in any one lighting and appliance branch circuit panelboard (one having more than 10% of its overcurrent devices rated 30 amps or less, for which neutral connections are provided).

While Section 384-14 apparently does not classify any branch circuit without a neutral conductor as a lighting and appliance branch circuit, the spirit of the code intent of Section 384-14 and 384-15 should be kept in mind. Basically, the limitation of 42 overcurrent devices in a single panelboard was imposed to limit the amount of heat accumu-

lated in the panel by continuously operated branch circuits such as lighting. Mercury-vapor luminaires can be connected to the ungrounded conductors of a 480/277-volt supply system in industrial or commercial installations. In this instance, no neutral connections would be involved. But heat accumulation will take place in a panel just the same. Therefore, it is good design to select panelboards with not more than 42 overcurrent devices in any instance where the majority of any type of branch circuits will be used for long periods of time.

Because mogul lamps may be connected to 50-amp circuits in commercial and industrial establishments, the same reasoning should apply even though 50-amp circuits are apparently not considered as lighting circuits, whether they can

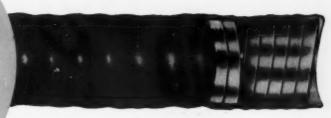


**UNIQUE METAL WEATHERPROOF** housing encloses panelboards which supply receptacles for portable 3-phase compressors in milk trucks. Fence and guard rail protect equipment from damage by trucks.

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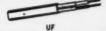












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The Amprobe Test-Master Kit, RS-3, Deca-Tran and Energizer are all products of PYRAMID INSTRUMENT CORPORATION, LYNBROOK, N.Y. WORLD'S LARGEST MANUFACTURER OF SNAP-AROUND TEST INSTRUMENTS

contain a neutral conductor or not. Section 384-14 states that a lighting and appliance branch circuit panel-board is one having more than 10% of its overcurrent devices rated 30 amps or less, for which neutral connections are provided. It is difficult to visualize that 50-amp mogul lighting circuits, used for long periods of time, should also not be a consideration in determining what constitutes a lighting and appliance branch circuit panelboard.

Section 384-16(a). A lighting and appliance branch circuit panel-board supplied by conductors having overcurrent protection greater than 200 amps shall be protected on the supply side by overcurrent devices having a rating not greater than that of the panelboard. An ex-

FREE STANDING switchboard has adequate gutter space for connection of feeder conduits. In this instance all connections to the board were made from the top of the board. Panelboards are a part of the switchboard in addition to feeder disconnects and volt/amp meters.

ception is where a panelboard is used as service entrance equipment. Panelboards other than lighting and appliance branch circuit panelboards are not required to comply with this rule.

Also, where lighting and appliance branch circuit panelboards are a part of an approved switchboard. the rules does not apply. This has been determined by the release of Official Interpretation No. 445, which reads: "Section 3883: Panelboard Protection-Question-Does paragraph a of Section 3883 (now Section 384-16) apply to a 200-amp circuit breaker lighting and appliance branch circuit panelboard installed in a deadfront switchboard section with a 400-amp service switch and fuse providing the only overcurrent protection ahead, where both the panelboard and the deadfront switchboard, in which it is incorporated, have been inspected and labeled by a laboratory of recognized standing prior to shipment from the factory? Answer-

Why this section applies to only lighting and appliance branch circuit panelboards has never been explained. Hence, good design practice will include observance of this section for all branch circuit panelboards.

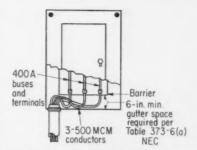
Section 384-16 (b) requires that the size of overcurrent protection not exceed 200 amps for all panelboards that contain snap switches, rated at 30 amps or less.

Where panelboards are installed in wet or damp locations, Section 384-17 requires that a 4-in. clearance be provided between the back of a cabinet or cutout box and the wall or other supporting surface. In wet locations cabinets and cutout boxes must be of the weatherproof type.

Section 384-18 requires that all panelboards be mounted in cabinets or cutout boxes.

Except where used as service equipment, all switches in panel-boards are required by Section 384-19 to be on the line side of fuses.

Section 373-3. Position in Wall. In walls of concrete, tile, or other noncombustible material, cabinets shall be so installed that the front edge of the cabinet will not be set back of the finished surface more than ½ in. In walls constructed of wood or other combustible material, cabinets shall be flush with the finished surface or project therefrom. When flush panel enclosures are



GUTTER SPACE DIMENSIONS for conductors No. 1 and larger, which are deflected in a panelboard, are given in Table 37-6(a), NEC. Sketch shows a typical example of application

mounted in the rough-in stage, it is extremely important that the installer verify the thickness of the finish wall material. This will assure a secure fit of the panel trim to the cabinet and panelboard interior when the finish is installed. While many panelboard interiors contain an adjustment screw to move the interior forward in the event the cabinet is not flush with the finished surface, the gap between the trim and the cabinet cannot be closed.

Section 373-6. Deflection of Conductors. Conductors entering or leaving cabinets or cutout boxes and the like shall conform to the following: (a) Width of gutters. Vertical conductors No. 1 or larger shall not be deflected where they enter or leave a cabinet unless a gutter having a width in accordance with the following table is provided:

Table 373-6 (a)—Width of Gutters

Table 010-0 (a) III dell	OT CHUCCE
	Minimur
	Width of
	Gutter
Conductor Size	in Inches
No. 1	3
0 to 00	31
000 to 0000	4
250MCM	41
300 to 350MCM	5
400 to 500MCM	6
600 to 900MCM	8
1000 to 1250MCM	10
1500 to 2000MCM	12

Sometimes larger feeder conductors are run to a panelboard to reduce voltage drop. If the conductors cannot be run directly to the connectors in the panelboard without deflection, an enclosure must be selected that has the gutter space provided in Table 373-6 (a).

Section 373-7(a) requires that cabinets and cutout boxes be selected which have sufficient space to accommodate all conductors in-

stalled in them without overcrowding. Often it is expedient to run two or three feeders in a single raceway to feed panels on various floors. This single raceway runs vertically to each panel from bottom to top. In such cases, panel enclosures should be selected that have additional wiring space. Due to the wide variety of panel enclosures for plug-in breakers and fuse blocks, this can be readily accomplished by resorting to a larger size enclosure than needed for the required number of branch circuit devices.

Section 373-10 (b) requires that cabinets and cutout boxes provide ample strength and rigidity. No. 16 USS gauge (.0598 in.) is the minimum size sheet steel permitted. Because of the wide use of aluminum conduits, there is a general interest in the availability of aluminum panelboard enclosures. A number of such enclosures have been made and installed. There are no provisions in the NEC or UL standards that would prohibit aluminum cabinets or cutout boxes. If the present interest in aluminum construction continues. aluminum panels will be readily available in the future. Because aluminum panels are not readily available at the present time, they must be custom made, and as a result, would cost more than steel panels.

It should be pointed out that numerous aluminum conduit installations have been made where steel cabinets were specified. And no adverse results have been reported where these dissimilar metals were joined together. Still, there can be no doubt that where aluminum conduit is specified, a superior installation would include aluminum cabinets, boxes and fittings.

### Switchboards-General

Switchboards contain switches, circuit breakers, fuses, metering equipment, relays or other forms of equipment which control or record electric current throughout a building. Widths range from 3 ft to over 100 ft. Most large installations today, particularly where loads exceed 1200 amps, use factory assembled switchboards for the control and distribution of current.

In all types of switchboards, good design includes extra capacity and spare overcurrent devices (or space for them) in the original specifications. This will permit additional

70 A, 6 - pole panel 9 in. H, 7 in. W, 3½ in. D

1-in. EMT 3No. 6TW

100 A, 12 - pole panel 14½ in. H, 10½ in. W, 3½ in. D

-1/2-in.EMT 6 No.6TW-

1st floor

Min

- USE THIS METHOD

to separate meters and 60 A pullout units in basement panel

APARTMENT BUILDING consisted of 27 units, nine per floor. Nine 2-in. EMT home runs were run to first floor panels. From there, 1½-in. EMT ran to second floor panels. One inch EMT fed third floor panels. Contractor had two options as shown in drawing. Method on the right was selected because oversize panels on first and second floors made a neater and less expensive installation.



TO AVOID THIS -

Pull boxes

**DEAD FRONT SWITCHBOARD** in an exhibition hall contains dimmers for general lighting, panelboards, and feeder circuit breakers. Pilot lights on the left indicate the lights that are in operation.

loads to be added later at minimum cost.

Major reasons for selecting switchboards over separate fused switch, breaker and gutter enclosures are reduced labor job costs and quality design.

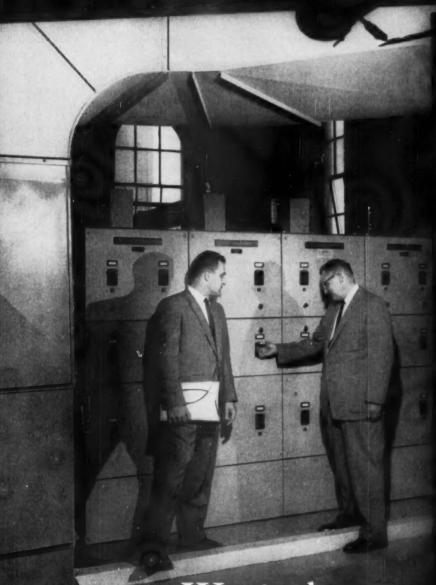


100A, 14-pole panel

171/8 in. H, 101/8 in. W, 37/8 in.D

THE OLD AND NEW are shown in the photo. Metalclad enclosed switchboard on the left replaces overloaded live-front board on the right in a typical modernization program in a department store.

Where sizes of any switchboard are wider than 40 in., they are usually made up in sections to simplify shipping and installation. Most job specs require construction in section panels. Even though switchboards are furnished in sections,



Contractor
planning
minimizes
electrical
modernization
costs

YOU CAN BE SURE ... IF IT'S Westinghouse





COVER PHOTO: William F. Lorenz, W. D. Gale, Inc., Electrical Contractors; and H. C. McDaniel, Branch Manager, WESCO, Detroit, examine new Westinghouse building-type switchboard which is used to protect and distribute power to upper floors of Buhl Building. Size and weight of equipment placed in this room had primary importance. Installation was made without enlarging doorway shown. COVER INSET: Buhl Building, Detroit, Mich., built in 1925, has long been one of the city's preferred business locations. Electrical modernization, completed in 1958, assures the building's continued "Class A" rating with adequate electrical facilities for many years to come.

M. E. Tisdale, Westinghouse Sales Engineer; Ralph E. Thomas; and William F. Lorenz check two banks of single-phase, 4800-volt Westinghouse dry-type transformers for operating audibility. (Three 100-kva units, and three 167-kva units with top connections housing the low-voltage leads.)



Close-up of building-type switchboard shows AB De-ion® type molded case feeder breakers. In background, Ralph E. Thomas; James E. Miller, Westinghouse Construction Sales Engineer; and William F. Lorenz are shown with three 100-kva DS-3 dry-type transformers. Westinghouse dry-type transformers were specified because of their smaller size and lighter weight. (Structural load had to be considered, as this converted rooftop room was not originally designed for equipment.)



William F. Lorenz, M. E. Tisdale and Ralph E. Thomas (who, in addition to being Building Manager, is a registered professional electrical engineer), discuss the electrical plans which resulted in maximum modernization of Buhl Building at minimum cost and inconvenience.

### Buhl Building modernizes to Build Business Electrically for next 20 years' growth

Plans for the electrical modernization of the Buhl Building in Detroit began with an analysis of the present electrical needs of the building and its tenants and a careful estimate of its possible requirements for the next 20 years.

The Building Manager, Ralph E. Thomas, worked closely with William F. Lorenz, Engineering Representative of the Electrical Contractor, W. D. Gale, Inc., Detroit, in preplanning the electrical system. It was decided to double the capacity by retaining the existing system to supply power to the lower half of the building. A new source for power distribution would then be installed on the roof of the building to supply the upper floors.

Westinghouse electrical equipment was specified for the installation, since special considerations of size, weight and quietness had to be satisfied. Included in this equipment was a Westinghouse building-type switchboard and Westinghouse DS-3 dry-type transformers. These were moved to the roof by the building's regular service elevator and installed in an existing room there. It was not necessary to enlarge any doorways or break through any walls. The minimum weight of the Westinghouse equipment permitted installation without structural reinforcement. In addition, the dry-type transformers were proved to be completely noiseless and vibrationless.

Important to both the contractor and the building management were the savings realized by this ease of installation. Final costs proved

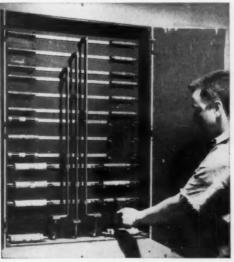
(continued)

# Westinghouse

J-94131-3



The primary oil circuit breaker arrangement shown will insure a power supply to building tenants under any fault conditions. M. E. Tisdale, William F. Lorenz and James E. Miller are in front of oil circuit breaker relay panel.





New Westinghouse Type FDP, completely safety protected combination switch and fuse panelboard, at right, has replaced the older, unsafe, live-front panelboard shown at left. This new panel not only safely protects all fuses and bussing, but the quick-make and quick-break switches provide positive opening and closing of the circuits.

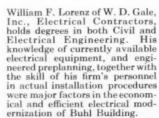


William F. Lorenz points out to Ralph E. Thomas and H. C. McDaniel the key interlock in handle of one of three Type LCB air disconnect switches. With these switches, transfer can be made from primary lines to insure constant power supply to lighting and power trans-formers in new electrical equipment room. The Westinghouse DS-3 single-phase dry-type transformers shown in rear each feed a section of the building-type switchboard.

The new pump and Westinghouse 50-hp Life-Line R moautomatically filled on the various floors of the buildefficiently than the two pumps and 50-hp motors previously used.









### **Buhl Building modernizes** to Build Business Electrically for next 20 years' growth (continued)

less than those estimated by both the contractor and management.

Westinghouse can help you in solving your modernization or new construction problems .. to Build Business Electrically.

See the Westinghouse distribution outlet nearest you or write Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pennsylvania.

OWNER: Buhl Land Co., Detroit, Mich.

ELECTRICAL CONTRACTOR:

W. D. Gale, Inc., (Members of Detroit Chapter, NECA), Detroit, Mich.

WESTINGHOUSE DISTRIBUTOR:

Westinghouse Electric Supply Co., Detroit, Mich.

### YOU CAN BE SURE ... IF IT'S

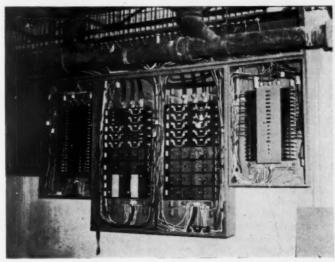
## Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV ALTERNATE FRIDAYS

J-94131-4



TYPICAL METHOD of supporting and connecting busbars in a large switch-board is shown. Bus stabs at the top of photo come from the serving utility vault.



**AUXILIARY GUTTER** above panelboards provides an effective means of distributing feeder and branch circuit conductors. Center panelboard is a split-bus type panelboard consisting of two separate bus sections, each with separate feeders.

one must check with the general contractor so that the board components can be installed at the proper stage of construction with the least amount of difficulty. Such large equipment can best be installed before door jambs or even complete walls are erected.

Because the requirements of serving utilities vary considerably, most large switchboards do not include space for the utility meters. CT space is provided on the board, and from there, metering circuits run to a separate wall space provided for metering equipment. In all cases, it is advisable to check with

the serving utility as to their metering requirements before switch-board designs are let out for bid. This is particularly true when doing an installation that is served by a utility unfamiliar to the designer. Only the serving utility will know how much space is to be required in a switchboard for their CTs, and how much room will be required for metering equipment adjacent to the switchboard.

### Types of Switchboards

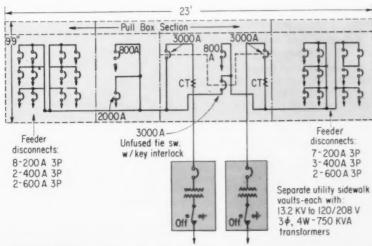
Generally, switchboards are classified in three types: 1) live-

front; 2) dead-front; and 3) safety enclosed-metalclad.

Live-front switchboards contain open knife switches, fuses or circuit breakers on the front of the board. Switchboards of this type must be located in separate rooms. which are accessible only to qualified persons. Because of high job labor costs, this type of switchboard is rarely used today. Also, large capacity equipment with resultant increases in weight make enclosed metalclad switchboards more desirable from a structural and safety point of view. Because high shortcircuit capacities are available, it is much safer to confine short circuits to metalclad equipment for the protection of personnel and the building proper.

Where replacements or additions must be made to existing live-front switchboards, consideration should be given to replace the board with a modern enclosed type. There is a limit to how much can be added to many old live-front boards, and replacements should be made in time to avert costly shutdowns.

However, obsolete equipment and panels can be replaced if the live-front switchboard is in good condition and not overloaded. In drilling new holes in slate or marble a standard steel twist drill may be used, provided the heel of the drill is ground off. This provides the drill with a sharper angle. Slate panels are drilled dry, while marble panels must be drilled with the use



**SKETCH SHOWS** a one-line drawing of a large switchboard connected to two utility supply systems. Tie switch can transfer load from one system to another.

of water. Avoid using excessive pressure when drilling through panels as this prevents breaking through the rear surface. Abandoned holes can be plugged with cement or plaster.

Dead-front switchboards are similar to live-front switchboards, except that no live-front parts are located on the front of the board. All exposed parts are located on the rear of the board, and these live parts are generally accessible. Much of the same comments which were said about live-front switchboards apply to this type of board. The same labor costs apply, and they do not offer complete protection of equipment due to exposed live parts on the rear of the board. Underwriters' Laboratories list this type switchboard, but the trend is toward the metalclad safety type.

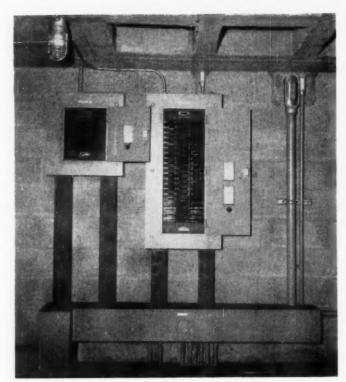
Safety enclosed, metalclad switchboards are the most common type of switchboard today. This type switchboard offers far greater protection to personnel and bus systems. However, the bus construction is quite different from those used on open switchboards, because the mechanical stresses are greater, and the space is limited.

### Switchboard Locations

Convenience of operation and proximity of loads are major objectives in selecting suitable locations for switchboards. Where switchboards constitute the service equipment, they cannot always be located near the supply loads. But in many instances, service raceways can be run in 2-in. concrete fill and be considered as outside of the building. Generally, the location of main switchboards is determined by the location of the utility supply.

Because of the size of switchboards on larger installations, separate rooms are generally specified. And due to the existence of high short-circuit currents at switchboard terminals, good practice, and a number of local ordinances, require two doors for switchboard rooms where the load exceeds 1200 amps. This will protect personnel who may be in the room at the time fault occurs. If only one door is provided, fire in the vicinity of the only means of egress would trap personnel or would restrict the work of fire fighters.

If switchboards are not located in a dry location, or, if they are located outdoors, they must be of



**SURFACE-MOUNTED PANELBOARDS** are connected to underfloor conduits through a series of auxiliary gutters. Gutters also contain a number of remote-control conductors, which control sectionalized buses.

the weatherproof type. Also, when switchboards must be installed in any hazardous location, a type approved for the particular Class and Division of hazardous area is required. The latter applies more to panelboards than switchboards, because switchboards can usually be located outside of the hazardous area. If at all possible, it is safer and much less costly to locate switchboards and panelboards in areas remote from hazardous locations.

### Selection and Mounting of Switchboards

Present and anticipated load is the first consideration in selecting a switchboard. This determines the main capacity of the board. Next, the number and type of feeder disconnects and overcurrent devices must be determined according to the need.

General mounting heights of switches and overcurrent devices include: a 7-ft maximum height from the floor or working platform to top of any overcurrent device; and centers of switches or breakers should not exceed 6½ ft from the floor below.

Service will enter the switch-



TWO SEPARATE PANELBOARDS are used to accommodate 40 lighting and appliance branch circuits. Panel to the right contains bottom-connected 3/0 double lugs. Feed to panels come from a 200-amp circuit breaker, which stabs into a 1000-amp busduct riser.

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# NEW Blackhawk 4" one-shot bender

Talk about spectacular savings — you pocket more than \$11 per bend over other methods. This new Blackhawk bender pays for itself on just a couple of jobs. From then on it's gravy all the way.

This portable bender goes right to the job. You eliminate about half of the fittings, pipe threading and the time it takes to make connections.

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CATALOG / MANUAL L-400 has full details on Blackhawk's family of time-saving, money-saving pipe benders. Write Dept. P-2050 today for your free copy.





### **BLACKHAWK®**

BLACKHAWK INDUSTRIAL DIVISION 13320 W. Reichert Pl., Butler, Wis. OTHER NEW PRODUCTS



Take the guesswork out of hand bending

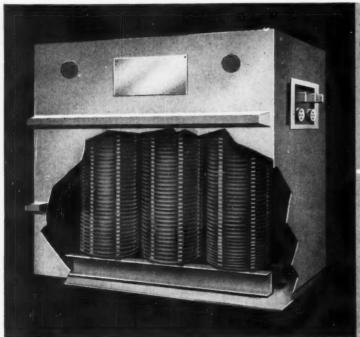
Here's Blackhawk's new rigid and thinwall hand bender that makes perfect 45° and 90° bends. As accurate as a carpenter's level, Blackhawk's Level Bender has unique double "bubbles" to do the figuring for you. You'll be amazed at the ease with which you make 90° bends, offset bends, saddle bends, back-to-back bends in ½2", ¾4" or 1" thinwall. Aluminum alloy construction is lightweight, yet built for hard work.

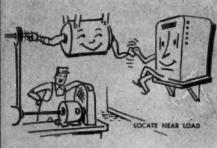


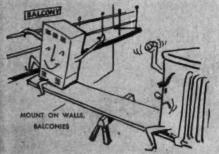
Ratchet Rig saves on "ells"

Foolproof ratchet action makes perfect "ells," eliminating the extra expense of manufactured ells. The rig is easy to operate — anyone can do it after a few minutes' instruction. Lock-on shoes are quickly interchangeable to bend rigid conduit or aluminum. An "Optik-Angle" gage assures bending accuracy. Ratchet Rig is either portable or can be mounted on a pickup truck.

## Power Where You Want It







### Check Inside: Where a Transformer Can be Located Is Largely Determined by its Insulation!

Whether you're modernizing or installing a completely new power distribution system, you can make certain that transformers will fit easily into any plant layout by specifying silicone insulated dry-type units.

Locate them near the load . . . on the floor, a balcony or the wall . . . anywhere! Insulated with Dow Corning Silicones, they are light-weight . . . space saving. Frequently no more expensive initially, they cost less to install, less to maintain, far less in the long run. Here's why:

Lowest Cost Installation: Easier to handle and easier to install, they require no costly vaults or barriers . . . can be placed right at load or load center for additional savings on costly low-voltage cable.

Lower Operating and Maintenance Costs: Virtually maintenance-free, silicone insulated transformers have no liquids to filter or change. Need no space heaters to keep windings dry when de-energized.

Maximum Reliability: Depending on design, they withstand overloads of 25% to 50% and more above rated capacity. The extra thermal capacity of silicones assures uninterrupted, reliable power.

Maximum Safety: Completely dry and completely safe, you can locate silicone insulated, dry-type transformers almost anywhere! No danger of fire . . . no toxic fumes. These units prove safe even under extreme overload and short circuit conditions.

Today, transformer manufacturers offer two basic designs insulated with Dow Corning Silicones — sealed and open dry-types.

For Load Center Unit Substations, you can achieve maximum reliability and minimum maintenance with a silicone insulated sealed dry-type unit. Requires only a periodic check of pressure gauge and bushings.

Or you can save weight by specifying a silicone insulated *open* dry-type unit. Up to 40% lighter than non-inflammable liquid filled units, they're ideal for balconies and other minimum floor loading areas.

Lighting Transformers and wall-mounted units are lighter per KVA than any other type. Locate them right at the load and save valuable floor space. They provide uninterrupted reliable power despite contaminated atmospheres, dust, dirt, moisture or high ambients.

Send today for full information on silicone insulated, dry-type transformers and list of manufacturers offering equipment insulated with Dow Corning Silicones.

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FEEDER DISTRIBUTION PANELBOARD is supported on an angle-iron structure at the base. At the top, gutters allow the connection of conduit feeders, and also connect to a wireway on the left, which contains main and sub-feeder conductors.

CLASS II, GROUP G, 12-circuit panelboard is mounted on channel bars, which are secured to concrete wall. Installation in a grain elevator,

board from a side or below or above the switchboard. When conduits supply the switchboard from the floor, it is important that the buses are elevated high enough to allow for the conduit stubs, bushings and bonding conductors.

Occasionally, smaller switchboards are surface-mounted on the wall. The weight is sufficient so as not to rely on wall anchoring devices alone. Supplemental support is recommended in the form of leg supports, which can be made with pipe stems and pipe flanges. This method is also recommended for large surface-mounted panelboards or similar enclosures.

If feeder conduits or cables enter the top of the switchboard, a wiring gutter is usually provided. Connections to the overcurrent devices are greatly simplified by the use of gutters, resulting in a neater job.

### **Panelboards**

Panelboards are required to be installed in cabinets. This makes them similar to safety-type metal-

- CARRENT - CARR

PANELBOARD INTERIOR is mounted in a specially designed enclosure for surface mounting on a column. Wiring trough extends to the ceiling, at which point, overhead conduits are connected. Feeder and floor outlet conduits are connected to bottom of cabinet.



A TYPICAL INSTALLATION of a flush panelboard installed in a block wall. Since cabinet was set even with the front of the blocks, the finished panel trim fits securely to the panelboard interior and cabinet without gaps around the perimeter of the trim.

clad switchboards. However, the basic difference between panel-boards and enclosed switchboards is that panelboards have no buses or devices requiring accessibility from the rear of the panel. Thus, all component electrical parts can be replaced or serviced from the front of the panel after the panel trim is removed. Also, panelboards are designed for flush installations as well as surface installations.

While all panelboards are alike electrically, they are generally classified as follows:

1. Service Equipment Panelboards. For loads up to 800 amps, panelboards are available which contain six or less circuit breakers or fused switches or pullouts. These panels constitute the service equipment and often contain split buses which supply branch-circuit overcurrent devices in the same enclosure.

2. Lighting and Appliance Branch-Circuit Panelboards. Over-current devices used in these panels are rated from 15 to 30 amps and supply branch circuits having two or more outlets.

3. Feeder Distribution Panelboards. Overcurrent devices for branch circuits larger than 50 amps are found in this type of panel, and sub-feeders feed from here to smaller branch-circuit panelboards.

4. Power Distribution Panelboards. These panels contain about any size overcurrent device and are generally used for 3-phase motor and similar power circuits.

Because of the wide variety and types of panelboards offered by a number of manufacturers, one should have a thorough knowledge of the types and ratings available.

Special panelboards can be obtained which include relays and contactors for applications having remote-control operation of various circuits.

Panelboards used in wet or damp locations or in hazardous areas should be of types approved for the specific location.

Locate all panelboards as near as possible to the load supplied. Mounting heights should not exceed 7 ft to the top overcurrent device, nor be less than 6 in. from the working surface below the lowest overcurrent device.

If it is intended that only qualified persons have access to the overcurrent devices in a panelboard, trims with a means of locking the doors should be specified.



### **Transformers**

higher distribution and utilization voltages in commercial and industrial electrical systems is stimulated by the availability of a wide variety of modern transformers. This includes transformers for stepping from one primary voltage down to a second primary level, for stepping from primary down to secondary voltage (not over 600 volts), and for stepping a secondary distribution voltage to a secondary utilization level. Such equipment varies in construction and installation requirements depending upon required kva capacity, voltage levels, and place of installation. A close look at types of transformers and application characteristics clarifies the tasks of effective selection and proper installation.

A basic outline of transformer classifications for modern application is as follows:

I—Up to 600 volts primary, lower voltage secondary.

A. Dry-type, single- and 3-phase, up to 750 kva.

1. Indoor applications

2. Outdoor applications

HE fast-developing trend to II—Primary rated above 600 volts, higher distribution and utiliza- up to 15,000 volts.

A. Dry-type, single- and 3-phase, up to 3000 kva.

Indoor applications

 Open dry-type

b. Sealed dry-type2. Outdoor applications

 a. Sealed dry-type
 B. Oil or askarel filled, singleand 3-phase, up to 7500 kva.

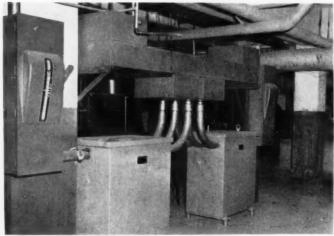
1. Indoor and outdoor applications

III—Primary rated above 15,000 volts.

1. Outdoor applications.

A. Oil or askarel filled, singleand 3-phase, up to 50,000 kva.

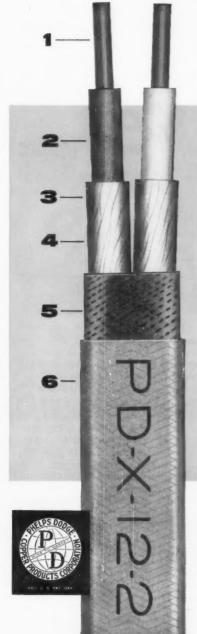
The above categories are general and cover a very wide range of specific types and sizes of transformers for indoor and outdoor application. In manufacturers' literature, the various types of transformers are designated according to their ratings and constructions. Various names are assigned to types of transformers according to their common use in electrical systems. The following names are



typical:

TWO TRANSFORMERS—each 225 kva, 480-120/208 volts, 3-phase, 4-wire, dry-type—operate in parallel and are installed in the basement of a convention hall as part of electrical modernization to handle 1200 tons of air conditioning. Each unit is fed through its own 3-pole, 600-amp, 600-volt disconnect switch (one at left, one at right) fused at 300 amps. Each transformer secondary consists of three 3-in. conduit circuits up to a 3-phase, 4-wire secondary busway above the units. Each transformer is supported by U-channel runners set on pipe legs. These units have bottom ventilating grilles and must be mounted off the floor.

# You can't beat Phelps Dodge Dependable PD-X Cable for fast, easy stripping!



Habirshaw type NM nonmetallic-sheathed cable saves vital on-the-job time and money!

Phelps Dodge Copper Products Corporation's PD-X cable is the fastest-stripping, cleanest-working nonmetallic-sheathed cable on the market today. Here's why:

- ¶ Copper conductors are *soft* drawn. Connections are easily and quickly made.
- 2 Habirdure Thermoplastic Insulation is clean and smooth —makes stripping simple, easy, fast.
- 3 Paper armor is resin-treated to resist moisture, is clean and dry—no oil, grease or wax is used.
- Paper armor is applied with a long twist and can be removed by an easy flick of the fingers. No time-wasting unwinding, no sticking to underlying insulation.
- Sarrier tape keeps finishing compounds out of the cable—leaves inside clean and free of gum. Strips off cleanly as a unit with outer braid covering.
- Clean, grey finish eliminates sticking, assures easy pulling, clean walls and hands.

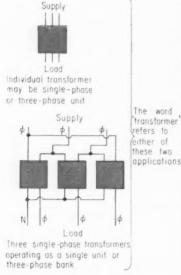
See Your Pheips Dodge Distributor I

## PHELPS DODGE COPPER PRODUCTS

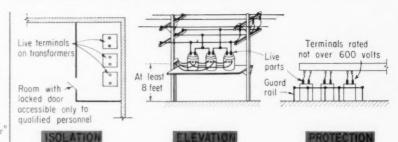
CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Dayton, Denver, Detroit, Fort Wayne, Greensboro, N. C., Houston, Indianapalis, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

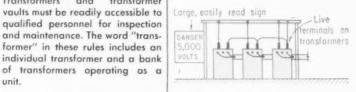
### CODE RULES OF TRANSFORMERS



1. Transformers and transformer vaults must be readily accessible to qualified personnel for inspection and maintenance. The word "transformer" in these rules includes an individual transformer and a bank



- 2. Transformers must be guarded as
  - A. They must be protected against physical damage.
  - Dry-type transformers must have a non-combustible, moisture-resistant case to protect against accidental insertion of foreign objects.
- C. Exposed live parts must be protected against accidental contact by: putting the transformer in a room or place accessible only to qualified personnel, by keeping the live parts at least 8 ft above the floor or by using a guard rail around the equipment when not over 600 volts.



D. Signs or other visible markings must be used on the equipment or structure to indicate the operating voltage of exposed live parts.

Note: The rules here do not apply to the following transformers:

1. Current transformer—such as used for metering or relay protection

against overcurrent.

unit.

2. Dry-type transformer which is a component part of other approved apparatus—such as transformer in a welding machine, control transformer in a motor starter.

3. Transformer for X-ray or high-frequency apparatus.

4. Transformer used with Class 1 low-voltage power circuits or Class 2 remote-control, low energy power or signal circuits-which must conform to Art. 725

Transformer for sign and outline lighting—which must conform to Art. 600.

Transformer for electric discharge (fluorescent and mercury vapor) lighting—which must conform at Art. 1410 on lighting fixtures.

General - purpose transformers are the dry-type units rated not over 600 volts and used for local step-down from a secondary distribution voltage to a utilization level. They serve lighting and appliance loads in all types of occupancies. Such transformers are also called "general power and light" transformers or simply "lighting" transformers. These include wallmounting, ceiling-suspended and floor-standing units and also control transformers.

Load-center transformers are either dry-type or liquid-filled units, primary rated from 2400 volts up to 15,000 volts and used for indoor and outdoor applications in highvoltage distribution systems to step to a voltage not over 600 volts. Such units may be used either separately, in combination with separate protective and switching devices and a separate secondary distribution switchboard, or they may be combined with primary and

secondary switching and protection in a packaged unit substation-also called a "load-center substation." These are base-mounted, freestanding units.

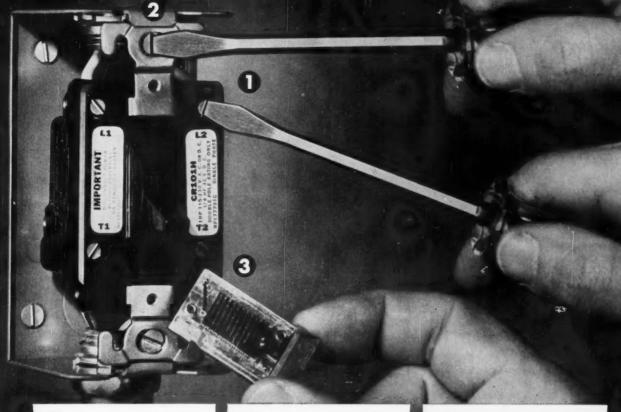
Distribution transformers are single-phase and 3-phase, oil- or askarel-immersed, pole-mounting or platform-mounting units primary rated from 480 volts up to 15,000 volts, with step-down to a secondary level or to a lower highvoltage level in the case of units over 10-kv primary. This type of transformer-in capacities up to 167 kva-is used for pole-line distribution. Other outdoor wiring systems use platform units with ratings up to 500 kva.

Substation transformers are oil or askarel units primary rated from 2400 to 67,000 volts, with secondary ratings ranging from below 600 volts up to 15,000 volts. Such units are designed for use in utility distribution substations and in industrial substations.

Power transformers are very large outdoor transformers used by utility companies in their transmission and distribution systems rated above 67,000 volts. Installation of such transformers must be made in strict accordance with the utilities' specs and standards.

Of the above types of transformers, only general-purpose transformers are discussed in this section. The accompanying code requirements and illustrations, however, apply to transformers in general, except where they specifically refer to dry-type units. It should be noted that the code data on dry-type transformers is also applicable to units operating over 600 volts. Transformers with connections rated above 600 volts are covered in the "High Voltage" section of this report. National Electrical Code rules which particularly apply to high-voltage transformer application are given in that section.

# HOOK-UP TIME: 2 MINUTES



Once G-E manual starter enclosure has been mounted on wall or machine, strip wires, insert in pressure-type terminals and tighten terminal screws. No looping necessary. All line terminals are at top, load terminals at bottom.

Position open starter in enclosure and tighten two screws. With wrap-around enclosure cover removed, maximum working room is provided. Compact design of the CR101 manual starter means easier handling, greater wiring space.

Mount heater. Exclusive design plugs in from front in 3 seconds and is keyed to eliminate chance of incorrect insertion. Ampere trip rating is molded on front of heater. Enclosure cover can be replaced by lightening two screws.



KIT PACKAGING of starter components provides 24 combinations. Included are key-operated starters and stainless steel flush plates shown above.

### General Electric CR101 Manual Starters Offer Unmatched Installation Convenience and Flexibility

Just 2 minutes to hook up the General Electric CR101 fractional hp manual starter. Multiply this advantage times the number of starters you install every year, and count your dollar savings.

And you can get the exact starter you need from General Electric—any combination of these components: standard or key-operated open starters; single-or two-gang back boxes; standard cover; and wide choice of flush plates—machine grey or stainless steel, for single-or two-gang installations, with or with-

out indicating light. Components are packaged in kits to save more installation time. No disassembly is required before wiring.

Next time you buy manual starters, try the G-E CR101. Ask your nearby G-E distributor for GEA-6358 and GEA-6976 or write General Electric, Schenectady 5, N. Y.

you get MEASURABLE ADVANTAGES
WITH GENERAL ELECTRIC CONTROL

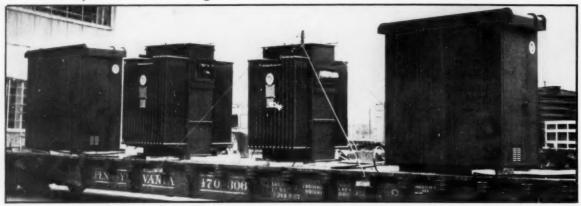
GENERAL



ELECTRIC

# Pennsylvania Transformer Announces a Complete Line of SECONDARY

All Components Designed and Manufactured Under One Roof



Coordinated shipment of all substation components is the practice at Pennsylvania Transformer. Switchgear assemblies and transformers are produced at the same plant.

## Tilt-back Feature Facilitates Inspection and Maintenance

A unique feature of Pennsylvania's drawout switchgear allows the breaker to be tilted back when in the withdrawn position. This is particularly important for maintenance and the adjustment of trip elements.

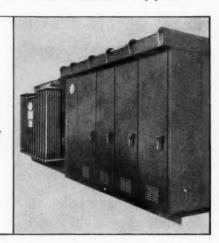
The racking mechanism is operated with a self-storing captive handle. Before it can be operated, the mechanism must be unlatched

with a lever that can be moved only with the breaker open. The mechanism locks in all positions. The compartment door can be closed with the breaker in any position.



Breaker shown in withdrawn and tilted back position for easy access to trip units.

Outdoor articulated Pennsylvania substation with oil-filled transformer. Substation is rated 1500 kva, 12,470-480Y/277 volts.





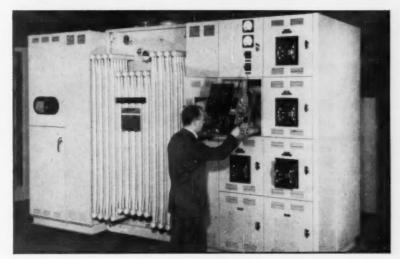
PENNSYLVANIA

Designed and manufactured by Pennsylvania Transformer

# UNIT SUBSTATIONS



- Centralized Responsibility Assures Coordinated Shipment of Components, Easier Installation.
- Products Include Indoor and Outdoor Substations
   —Articulated and Integrated.
- All Substation Components Designed in a Separate, New Department, by an Experienced Staff of Switchgear and Transformer Engineers.
- Low Voltage Switchgear Manufactured in New Facilities Adjacent to Transformer Plant.
- Pennsylvania Assumes
   Complete Responsibility
   For Materials, Workmanship and Operation of
   Complete Unit Substations. Perfect Fit and
   Matching Appearance of
   Components Guaranteed.



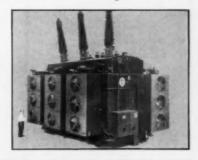
Pennsylvania Transformer's new line of secondary unit substations includes both indoor and outdoor designs. Pictured is a 1000-kwa articulated, indoor substation rated 4160-480Y/277 volts. The substation includes a primary, fused, air-interrupter switch, an askarel-filled transformer, and secondary drawout switchgear with a feature that allows the breaker to be tilted back for inspection and maintenance.

## Pennsylvania...Builder of Load Center Transformers for Many Years

Pennsylvania Transformer enters the secondary unit substation field with a background of over 30 years' experience in designing and building distribution, power and load center transformers for America's leading utilities and industrials.

### 315,000-KVA

power transformer manufactured by Pennsylvania Transformer Division for a large midwestern utility.





### Write for Copy of Pennsylvania's Secondary Unit Substation Book

This well-illustrated 44-page booklet, No. PSG 559, contains descriptions of secondary unit substation and switchgear components, as well as application data. Write for a copy on your company letterhead.

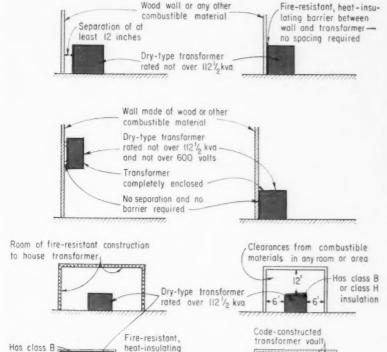
### UNIT SUBSTATIONS

Division, McGraw-Edison Company, Canonsburg, Pa., Greater Pittsburgh District



### CODE RULES:

### MOUNTING DRY-TYPE TRANSFORMERS INDOORS



barrier protecting

combustible materials

in any room or area

No special spacings between transformer and combustible materials

or class H

insulation

DRY-TYPE TRANSFORMERS installed indoors must conform to the following:

A. Units rated 1121/2 kva or less must be mounted at least 12 in. from combustible material unless a fire-resistant, heat-insulating barrier is used between the transformer and the combustible material or unless the unit is rated not over 600 volts and is completely enclosed except for ventilating openings.

### 600-Volt Dry-Type Transformer

Any transformer develops heat due to energy lost during operation. Because removal of this heat is important to proper operation and greatly influences size and construction, transformers are most commonly differentiated according to the method used for cooling and insulating. There are dry-type transformers, which use air circulation or dry gas such as nitrogen for cooling, and liquid-type, which use

B. Units rated over 112½ kva must be installed in a transformer room of fire-resistant construction unless they are Class B or Class H insulated and are separated from combustible material by 6 ft horizontally and 12 ft vertically or are separated by a fire-resistant, heat-insulating barrier.

Any dry-type transformer

rated at more than 15,000 volts

C. Transformers rated over 15 kv must be installed in a codeconstructed vault.

mineral oil or a synthetic, non-inflammable cooling liquid called "askarel" to cool and insulate the coil and core assembly. Generalpurpose transformers are of the dry type, using air circulation for cooling.

One of the fast-growing trends in modern electrical design is the use of general-purpose transformers in conjunction with 480-volt secondary distribution systems. The widespread use of 480Y/277-volt (or nominally rated, 460/265-volt) systems for large-area fluo-

rescent and mercury-vapor lighting has created demand for local stepdown transformers-in ratings up to 500 kva-to supply 120/208 volts or 120/240 volts for incandescent lighting, appliance loads, and receptacle circuits. And recent code expansion of the permissible application of such systems will further increase use of general-purpose transformers. Now 277-volt lighting is permitted in industrial establishments, office buildings, schools, stores and public and commercial areas of other buildings, such as hotels or transportation terminals. Where any of these types of buildings take advantage of the substantial economies of 480/277-volt distribution for power and light, stepdown transformers will be needed. Of course, transformers will also find application in 480-volt and 240-volt delta-connected systems, to supply lighting and appliance loads.

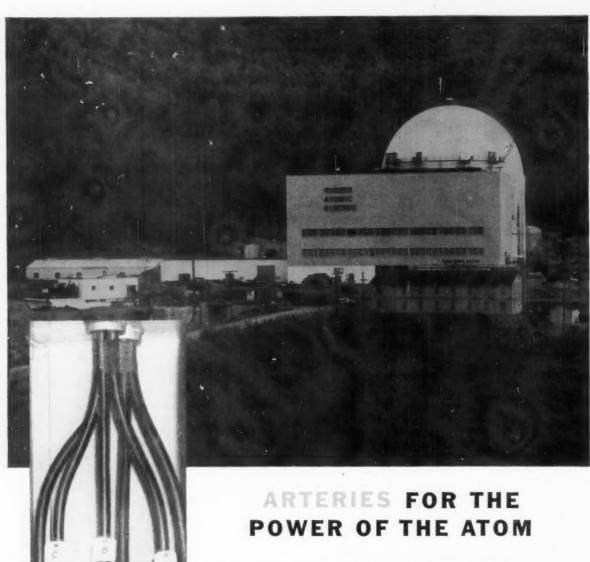
### Construction

Typical construction characteristics of general-purpose transformers are as follows:

Housings - Air-cooled, dry-type transformers are generally enclosed in sheet-metal housings. The enclosure may or may not be ventilated. Completely enclosed units are made to permit use in atmospheres where dust, moisture, chemicals or other airborne matter might harm exposed coils in a ventilated case. Some units have their core laminations exposed to dissipate heat. Other small-size units have totally enclosed housings filled with epoxy compound which seals the windings against atmospheric attacks and greatly reduces operating hum of the transformer. Totally enclosed units are commonly referred to as dust-tight and suitable units are made for outdoor use. Ventilated enclosures have openings which permit natural circulation of air over the winding assembly.

Raceway connections — Transformer housings are generally suitable for connection to all standard wiring systems—rigid or thinwall conduit, flex, busway, non-metallic cable or open wiring. Enclosures are provided with single or multiple-concentric knockouts to accommodate various sizes of conduit. And enclosures have removable panels for ready work inside in connecting conduit and wires.

Mounting provisions - Various



In Rowe, Massachusetts, the Yankee Atomic Electric Company has built one of the first commercial atomic power plants in the U.S.

This engineering marvel, designed to transform the destructive power of the atom into useful electrical energy, utilizes no less than 200,000 feet of Simplex wire and cable, some of which is exposed to radiation.

For top performance in all types of installations, utilities and industrial companies the world over rely on the products of Simplex research and development.



Simplex

1885 Diamond Jubilee 1960 75 Years of Leadership in the Wire and Cable Industry

WIRE & CABLE CO.

Cambridge, Mass. . Newington, N. H.

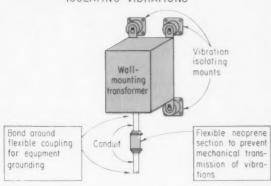
### MINIMIZING TRANSFORMER NOISE

 Use solid mounting when the unit can be secured to a heavy, solid mass which cannot vibrate audibly. Such would be reinforced concrete—floor or wall.

2. Use flexible mounting for mounting on a structural frame, wall, ceiling or column. Such mounting makes use of special rubber vibration isolators called "flexible mounts." There must be no solid metal contact between the transformer and the mounting surface. Such would "short-circuit" the vibration impedance of the mounts.

3. Flexible couplings between the wiring system and a transformer can isolate the conduit system and other mechanical parts from picking up the transformer vibrations.

ISOLATING VIBRATIONS



4. Mount the transformer as far away as possible from corners on other junctions of large flat surfaces which

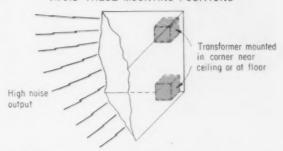
only serve as sound reflectors to raise the apparent level of transformer noise.

A. Avoid installation in narrow halls or in corners of stairwells.

B. Keep the transformer as far away as possible from the area in which its noise would be most objectionable.

C. In particular, avoid mounting in a room corner up near the ceiling. Such three-sided corners act as megaphones.

AVOID THESE MOUNTING POSITIONS



5. Where necessary, cover walls with acoustical damping material—fiberglas, acoustical tile, kimsul and similar absorbent materials—to reduce propagation of transformer noise from a transformer room to any adjacent areas. It should be noted, however, that such material has major effect on the high harmonics of transformer noise but has little effect on the fundamental.

Where possible, experimental placing of a floormounted transformer in a room or area and temporary operation of the unit will quickly indicate best location and

orientation of the unit.

types of brackets and keyhole slotted hangers are provided for wallor ceiling-mounting of transformers, with lifting eyes or holes to raise units into their mounting positions. Some units have universal mounting bars for installation in any position—wall, ceiling or floor. Floor-mounting units have lifting eyes and mounting feet on the bottom where necessary to provide bottom ventilation.

Terminal space—Suitable compartments are provided to facilitate primary and secondary circuit connections. Some units have separate compartments for primary and secondary terminals; others use a common space within the housing. Many units have the terminal connections at the bottom part of the housing to minimize the effect of heat on the lead wires. Terminal connections are identified as to primary and secondary, with each one numbered to provide proper connection of the unit for any given primary and secondary circuit configuration and voltage. A cover or panel provides access to the terminal compartment.

The use of diagrammatic nameplates, which show proper connections of the identified transformer terminals and list other specs on the unit, greatly simplifies the matter of transformer installation. Additional wiring hookup information may be included on a diagram in the wiring compartment.

Insulations — Dry-type transformers are designed with different types of insulations on the windings and other parts to suit them to various application requirements:

Class "A" transformers, when properly loaded and applied in an ambient not over 40°C, will operate at no more than 55°C rise on the winding. Class "A" transformers are physically larger and heavier than corresponding sizes of Class "B" transformers.

Class "B" transformers, when properly loaded to rated kva and applied in an ambient not over 40°C, will operate at no more than 80°C rise on the winding. Class "B" units are about half the weight of Class "A" units, for corresponding sizes.

Class "H" transformers, when properly loaded to rated kva and applied in an ambient not over 40°C, will operate at no more than 150°C rise on the winding. Such

transformers use inorganic insulations impregnated with silicone compounds and varnishes to achieve the high temperature rating. Class "H" insulated transformers are generally smaller and lighter than those with other types of insulation.

#### **Noise Considerations**

Transformers produce a characteristic noise-actually a hum-due to vibrations in the laminations structure. This hum has a fundamental frequency about twice that of the applied frequency. The relative loudness of this hum depends upon the construction characteristics of the transformer itself and the manner in which the transformer is installed. Some transformers are specially designed to minimize the noise produced by operation. Other transformers are not specially constructed for low noise level. And then installation of the transformer will affect whatever level of sound is produced. If the unit is mounted in such a way that the noise vibrations are mechanically transmitted to a large vibrating surface-such as sheet



LOCAL 30-KVA TRANSFORMER in 480/277-volt distribution system in a modern high school steps voltage to 120/ 208-volt, 3-phase, 4-wire level for receptacle outlets, miscellaneous incandescent lighting and fixed appliances. Unit is mounted in mechanical room--one of four such rooms with identical layout, serving classrooms in the building. Secondary connections from transformer are carried in flexible metal conduit to an auxiliary gutter below the 120/208-volt panel. Transformer is set on channel-iron runners. Each of the four mechanical rooms-one above another at each side of the school, is a very narrow and small room with a large louvered vent opening to the outdoors at one end. The size and venting of the room acoustically tune the area to a sound frequency close to the higher harmonics of magnetostrictive vibration in the transformer. To minimize the effect of this sound reinforcement, the concrete-block walls of the room are covered with 2-in, thick Fiberglas. This application does eliminate sound propagation into the adjacent classroom. course, the use of a relatively quiet transformer is a big advantage here.

metal or wood—the sound can be mechanically amplified so it is much louder than that coming directly from the transformer. Or installation may be made in such a way—in the corner of a room or close to large reflecting surfaces—that the sound level from the unit is given an acoustical level boost (the way a horn or megaphone operates). In some cases of poor mounting, a special quiet-type transformer can produce a louder sound output than that of an ordinary transformer carefully mounted.

In any installation, the relative importance of transformer noise depends upon the normal ambient noise level of the area. Where ambient noise level is high—such as many industrial plants or places

where operating machinery produces a fair level of noise, the noise produced by standard transformers is completely "masked" and no problem exists. But in areas where the ambient noise level is low—such as libraries, schools, office interiors, hospitals, churches, theatres, etc., transformer noise can be a serious problem. In these latter cases, steps must be taken to reduce the objectionable transformer hum.

To facilitate solution of the transformer noise problem, manufacturers are rating their transformers in levels of noise production. The key to this rating method is a unit of measure of sound level known as the "decibel." As an indication of the use of this unit, the following is a table of common average noise levels expressed in decibels (abbreviated "db"):

10 db—a very quiet day in the country

20 db-quiet talking

45 db-a quiet office

65 db-office with business ma-

75 db—average factory

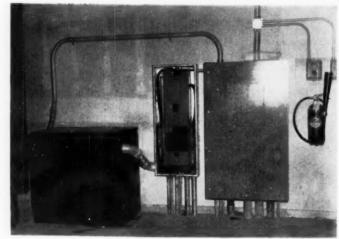
105 db-a boiler factory

To correspond to our familiarity with such noise levels, transformers are rated in decibels of sound level:

	Average	
Transformer size	sound level	
0- 9 kva	40 db	
10- 50 kva	45 db	
51-150 kva	50 db	
151-300 kva	55 db	
301-500 kva	60 db	

From this db table, transformers can be compared with sound level at the place of their installation. A basic rule on selection is to choose a transformer with a measured sound level lower than the ambient noise level at the place of installation. That is, the db level of the transformer must not be higher than the average db level of the room or area in which it is mounted. However, it must be kept in mind that the sound level of a transformer as measured under test conditions at the factory may not be the same on the job. Due to mechanical and/or acoustical conditions, the level may be considerably higher. The objective must be to keep the "job-installed noise level" of the transformer below area ambient noise. And where ambient noise is considerably higher than the decibel values in the transformer table, special low-noise transformers and special installation do not have to be used.

Available transformer units vary in their sound output. Larger units are louder than smaller units. Special quiet-type units have much lower levels than standard transformers. In general, a Class A transformer of given voltage and kva rating is quieter than the same size Class B transformer; although there are no standards on the basis of insulation class. The difference in sound levels of standard transformers should be checked when selecting a unit for the middle range



**LOAD CENTERS** in a 480/277-volt distribution system for a modern shopping center are built around dry-type transformers, such as in this load center serving a variety store. The transformer is a 3-phase 75-kva unit, stepping voltage to 120/208 and mounted in a second floor mechanical room above the store itself. Secondary conductors are carried in flexible metal conduit into the center panel. A bare ground conductor is used as a bonding jumper around the flex section. The unit is set on the floor on flat steel mounting members.

# Flush-Fit Couplings on L-M Permaline Conduit Provide Big 3-Way Savings



SAVINGS IN STORAGE are realized since the coupling is attached to the conduit. Coupling cartons are eliminated.

SAVINGS IN HANDLING are possible because the coupling is attached to the conduit at the factory. No cartons to check in and out of your warehouse.

Big savings are possible with L-M Permaline Conduit and the Flush-Fit Coupling. The couplings are installed at the factory on one end of each 2, 3,  $3\frac{1}{2}$ , 4,  $4\frac{1}{2}$  and 5-inch sizes of Permaline Conduit. Thus, you save in three important ways since the coupling and conduit are bought, stored and installed as one complete unit:

Savings in Storage . . . coupling cartons are eliminated.

Savings in Handling...coupling and conduit are one unit. Savings in Installation...coupling is already attached; no couplings to attach on the job site.

L-M Flush-Fit Couplings have the same outside diameter as the conduit. Joints do not have to be staggered. You install Permaline conduit as fast as you can get it into the trench.

### **Other Permaline Advantages**

Permaline Conduit offers many other time and money-saving advantages:

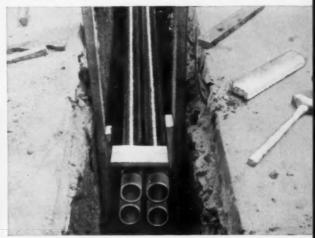
Smoother Inner Bore... Faster, trouble-free cable pulling. Choice of Shipping Methods . . . Bulk, fork-lift bundles or steel-strapped slings for fast, easy handling.

Complete Line . . . All sizes; 5, 8 or 10-foot lengths; all accessories.

Complete Stocks At Strategic Warehouses . . . One is conveniently located near you.

Exceptional Service . . . More than 100 Permaline representatives in the U. S. ready to serve you.

Engineering Service...Complete technical assistance on your proposed system.



SAVINGS IN INSTALLATION are possible because coupling and pipe are taper-fitted, and need only be driven with wood block and hammer to provide tightest possible joint.

Get Complete Information . . . For complete information on Permaline Conduit with Flush-Fit Couplings or any Permaline product, contact your L-M Field Engineer or Permaline Specialist; or, write Line Material Industries, Milwaukee 1, Wisconsin; ask for a copy of L-M's Underground Construction Handbook, 12-point Plan Folder and Permaline Conduit Bulletin UG1A. In Canada: Canadian Line Materials, Division of McGraw-Edison Company (Canada), Limited, Toronto 13, Ont.



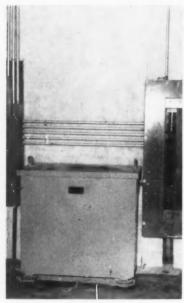
## **LINE MATERIAL** Industries

MCGRAW-EDISON COMPANY



42

## Permaline Fibre Conduit



150-KVA TRANSFORMER in a school is mounted between 480/277-volt panel, at right, and auxiliary gutter, at left, carrying 120/208-volt secondary conductors from which motor starters and several subfeeders are tapped. Transformer is fed by 3-pole 225-amp CB in panel. Reduction of noise propagation is very effective. Couplings to the transformer are rigid, but the unit is set with its channel-iron runners on non-metallic vibration-damping shim pads. And the room is Fiberglas covered on concrete walls and ceiling to reduce sound propagation, even though the room is adjacent only to the gymnasium which has a normal ambient noise level high enough to mask the sound output of a 150-kva transformer. There is no noise intrusion upon the quiet of classroom and office areas in the school.

of ambient noise levels. Often, a sufficiently quiet standard unit, in combination with skillful installation, will eliminate the need for an exceptionally quiet unit. However, for many very quiet commercial areas—schools, offices and hospitals—the use of special quiet-type transformers will be mandatory. And so will skillful installation.

### **General Installation**

In all transformer installations, instructions of the transformer manufacturer should be carefully observed in setting or mounting the unit and making the connections. The following are general rules covering the installation of dry-type transformers:

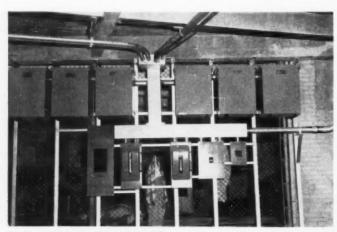
Handling-Transformers should be moved right side up, with care taken to avoid denting the sheet metal enclosure. They should not be dragged, rolled or slid to their mounting location. Instead, the lifting eyes or holes should be used to lift and transport the unit on and off any rolling truck which is used to carry the unit. If means of lifting the unit off the ground is not available, careful rolling or dragging can be used provided the wood packing case is on the unit and pipe rollers or suitable skids are used. Avoid use of steel rope slings in lifting. They generally cause damage to the case. When handling ventilated dry-type transformers outdoors during inclement weather, protect the unit against entrance of rain or snow by use of a plastic or canvas cover.

Locating—A transformer should be located where it is readily accessible for hookup and maintenance. It should be kept away from very quiet areas where its noise would override ambient noise level. The location should always be such that the noise from the unit is not amplified by acoustical conditions at the place of installation. And National Electrical Code rules should be strictly observed in selecting the location for the unit, to assure no dangerous proximity to combustible material.

Care should also be taken to select a place with as dry and clean an atmosphere as possible for installation of open-ventilated transformers. Exposure to dripping or splashing water or other wet conditions should be avoided, or proper protection must be provided. Outdoor application calls for a housing suitable for such use. And temperature at the place of installation must be normal, or the transformer may have to be derated.

Ventilation at the place of installation is another important requirement. Dry-type transformers depend upon circulation of clean air-free from dust, dirt or corrosive elements-for proper cooling. Filtered air is preferable; and, in some cases of extreme air pollution, it may be mandatory. In any case, it can reduce maintenance. In restricted spaces - small basement mechanical rooms, etc.—ventilation must be carefully checked to assure proper operating temperature of the transformer. The usual requirement is for 100 cu ft of air movement per minute for each kilowatt of transformer loss. Area of vent openings should be at least 1 sq ft each of inlet and outlet openings per 100 kva of rated transformer capacity, after deducting area occupied by screens or grates in the openings. Height of vault, location of openings and loading of a transformer affect the ventilation requirement, One manufacturer calls for the areas of the inlet and outlet openings to be not less than 60 sqft per 1000 kva when a transformer is operating under full load and is located in a restricted space. And a distance of at least 1 ft should be provided on all sides of a dry-type transformer and between adjacent

The place of installation must not expose the transformer housing to damage by normal movement of



WALL-MOUNTED TRANSFORMERS in this covered parking lot are secured to an angle-iron frame mounted between the floor and ceiling, as shown. Each unit is a single-phase 480-120-volt transformer with the three at left forming a 3-phase bank and the three units at right forming another 3-phase bank. This use of individual units permits supporting the total weight in a distributed manner on the frame, providing a large amount of transformer capacity from a wall-mounted installation. Units are nippled together, as shown.

# NEW! Exclusive 55° Angle Lighting Louver Diffuser

Developed to meet todays and tomorrows higher lighting levels—For use in Individual fixtures, Modular or Large Area illumination with unexcelled diffusion—Developed to meet and exceeds IES-NEMA SPI joint specifications for stabilized styrene—True translucent white and a wide range of colors—Light weight for easy handling, installation and maintenance—Dimensionally stable—Low cost—Available in 45° and 42° shielding also.

CELL OPENING: 13/32" x 13/32" x 1/2" HIGH

Light shielding louvers is our one and only most important product, developed, designed and manufactured by American louver, consultants to the lighting industry since 1939, assuring you the finest in Plastic Louvers.

For pertinent facts on American louvers, write for bulletin 33am and new 3 color catalog— Just off the press. When Specifying!!!

you can depend on

American Louvers.

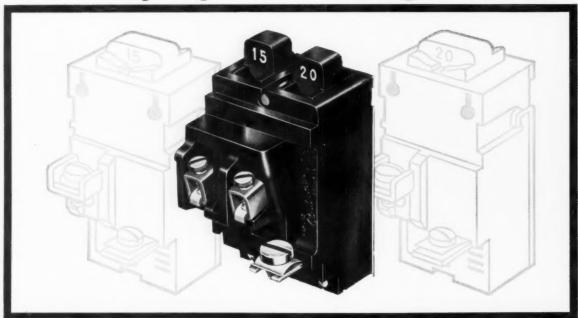
american louver company

4240 N. SAYRE AVENUE . CHICAGO 34, ILLINOIS

BullDog's

# NEW DUPLEX

The only space-saving breaker



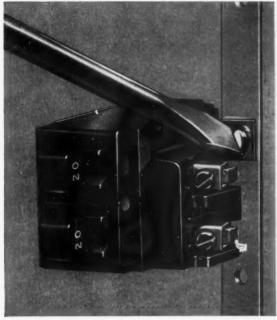
1. SPACESAVER. New Duplex Pushmatic® breaker puts two breakers in the space of one single breaker. You get more electrical circuit flexibility with smaller panels; and 15- and 20-amp capacity, in any combination.

2. DOUBLE PROTECTION. Duplex is the only 2-in-1 breaker that gives coil-magnetic short-circuit protection, as well as thermal overload protection, for each circuit. Provides identical, independent coil protection in each pole.

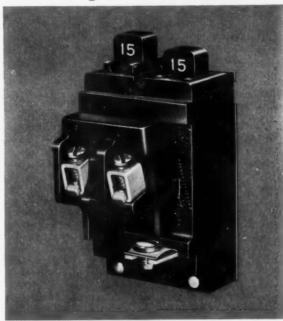


# JSHMATIC!

with coil-magnetic protection!



3. ONE BOLTED CONNECTION. Duplex provides a single positive bolted connection to bus bar. Electrical contact is under constant pressure, won't work loose, won't overheat. Installation is quick and easy.



4. PUSHBUTTON CONVENIENCE. Only Duplex Pushmatic has pushbutton convenience. Pushbutton pops up, can be identified instantly by sight or touch. You reset it with a push of the finger. Simple, fast, foolproof!

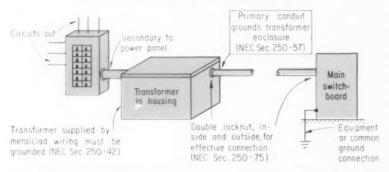
BullDog Electric Products Division, I-T-E Circuit Breaker Company, Box 177, Detroit 32, Michigan. In Canada: 80 Clayson Rd., Toronto, Ont. Export Division: 13 East 40th St., New York 16, N. Y.



BULLDOG ELECTRIC PRODUCTS DIVISION I-T-E CIRCUIT BREAKER COMPANY

### CODE RULES

### TYPICAL GROUNDING OF TRANSFORMER CASE



### EXPOSED NON-CURRENT CARRY-

**ING** metal parts (which are likely to become energized) of transformer installations — including fences, guards, etc. — must be grounded under any of the following conditions:

- A. Where supplied by metalclad wiring—armored cable, conduit, flex, busway.
- Where located in a wet location and not isolated.
- C. Where located within reach of a person who can make contact with ground or grounded object.
- Where installed in a hazardous location.

- E. Where installed in contact with metal or metal lath.
- F. Where equipment operates with any terminal at more than 150 volts to ground, unless mounted 8 ft above ground on a wooden pole.

Grounding of transformer housings must be made by connection to grounded cable armor or metal raceway or by use of a grounding conductor run with circuit conductors (either a bare conductor or a conductor with green colored covering) or by a separate grounding conductor installed the same as a grounding conductor for equipment, Sec. 250-92 (b).

men, trucks or equipment. Ventilating openings should not be exposed to accidental or mischievous poking of sticks or rods into the windings. And protection against entry of small animals or other foreign objects should also be considered.

Mounting - The transformer should always be mounted in an upright position for effective ventilation, unless manufacturer's instructions specifically permit other mounting positions. The wall or floor on which the unit is mounted must be sufficiently strong to support its weight. Manufacturer's instructions must be followed in securing the mounting brackets to the wall or floor. Where transformer noise must be kept to a minimum, vibration isolation pads should be used in mounting the unit, and other mounting methods, shown in an accompanying box, should also be used.

Floor-mounted units with metal grilles on the bottom must be mounted up off the floor to provide the intended ventilation draft up through their housings. Regular shipping lumber can be used for elevating a unit and simultaneously serving as vibration isolation.

Another important consideration in the installation of dry-type transformers is the possible need for providing impulse protective devices. Dry-type units do not have the electrical impulse-strength of liquid-immersed transformers of the same ratings. Where they will be exposed to lightning strikes or heavy switching transients, proper protective equipment must be provided.

Connecting—Connection of the transformer to the wiring system consists of coupling any raceway to the enclosure and then connecting the supply conductors and the load conductors. The most common application finds conduit as the raceway connected to the housing. And in such systems, the primary circuit conduit usually grounds the transformer housing and, as a result, the secondary conduit and all metallically connected enclosures for conductors and equipment on the secondary side of the transformer.

When open-wiring (without any raceway) is connected to a transformer housing, protection must be provided for the conductors where they pass through the knockout

opening in the case. An insulated connector or Chase-nipple should be used.

When connecting a rigid conduit system to a transformer housing, provision can be made to afford ready removal of the transformer at any time without disturbing the conduit system. With ordinary rigid and thinwall conduit terminals, removal would require movement of either the conduit or the transformer. However, use of an electrical-type union-such as an Erickson coupling or split coupling -in the conduit close to the transformer will provide for ready removal of the unit at any time. Or a threadless conduit connectorwhich will also provide ready removal—can be used for connecting to the housing. For connections of conduit or any metal raceway or metal-sheathed cable containing conductors of more than 250 volts to ground (such as the primary in local transformers for 480/277-volt systems), the NE Code requires assurance of ground system continuity. This may be done by any of the following methods:

- 1. Threaded boss on the transformer housing, with joint made up tight.
- 2. Bonding jumper to assure lowimpedance current path from the conduit to the housing, using a bonding bushing with one locknut and a jumper to the housing—



GROUNDING CONDUCTOR for the secondary neutral and the housing of this 480-120/208-volt, 3-phase, 4-wire transformer is bolted to the external copper grounding strap on the housing. The neutral from the transformer secondary winding is connected to the same grounding strap inside the case. The grounding conductor is carried into conduit where it enters the floor and is run in the conduit up in the wall to a point near the ceiling where it emerges and is welded to another copper strap which is welded to an I-beam of the building's steel structure.



NOTICE!

60 Second Contact Convertibility

# ALLEN-BRADLEY CONTROL RELAYS

can thus easily be changed from N.O. to N.C. (or vice versa)

Why not give yourself a real surprise! We refer to the ease with which you can convert the contacts of these Allen-Bradley Bulletin 700 Type BR control relays. Using only a screwdriver, contacts can be changed from normally open to normally closed (or vice versa) in seconds—without removing the relay from its mounting—or its wiring. This "on-the-spot" convertibility certainly suggests an appreciable moneysaving reduction in your relay inventories.

Extensive tests have proven conclusively that the Bulletin 700 Type BR relays are good for many—and we mean many—millions of trouble free operations. A "built-in" permanent air gap completely eliminates all possibility of magnetic sticking. Naturally, the double break, silver contacts never need attention. Also, the molded coil is your assurance that even the most severe atmospheric conditions cannot cause trouble. Please write for full details on these relays today!



### **BUT HEAR THIS!**

In the event that when "on-thejob" it is discovered that something was either overlooked or added, the standard Bulletin 700 Type BR—either 2, 4, or 6 pole relay—can easily have added to its base, out in the field, either one or two switching poles. It is done as easily as "falling off a log."



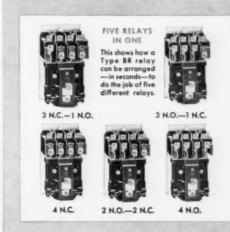
General-Purpose NEMA 1



Explosion-proof NEMA 7



Waterproof NEMA 4



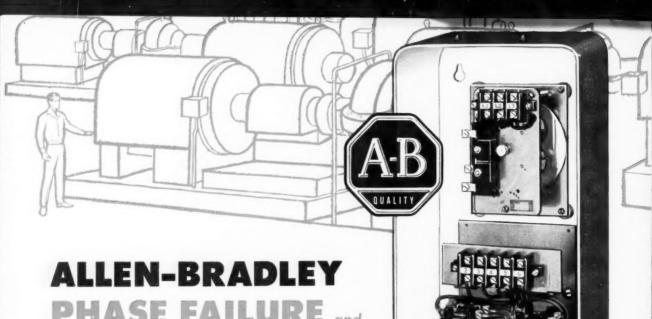
8-60-81

**ALLEN-BRADLEY** 

Member of NEM

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. . In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL



# PHASE FAILURE and PHASE REVERSAL

## RELAYS

# will provide positive protection for high-horsepower, high-priced motors!

It's sound "economy" to guard your investment in expensive motors and equipment against the extensive damage that can result from a phase failure or phase reversal. Allen-Bradley's Bulletin 812 Style RF relay provides complete, positive protection against both of these hazards.

The Bulletin 812 Style F phase failure relay instantly detects all open phase conditions on a motor branch circuit and removes the motor from the line—yet is not subject to nuisance dropouts from transient line fluctuations. An unusual feature of this Style F relay is its positive response, regardless of motor load or type of motor branch circuit employed.

The Bulletin 812 Style R phase reversal relay disconnects the motor from the line—whether it is running or not—when a phase reversal occurs on the line side of the relay. Thus, it can be used to protect a single motor or a group of motors. Furthermore, the Style R relay removes the motor from the line should a phase failure occur while the motor is stopped.

All A-B Bulletin 812 relays are completely "fail safe." It will pay you to investigate this economical insurance against the heavy losses that can—and *frequently* do—result from phase failure and phase reversal. Write today!

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

Bulletin 812 Style RF for
Phase Failure and Phase Reversal consists of
Style F Phase Failure and Style R Phase Reversal relays in the same enclosure.



Bulletin 812 Style F



Bulletin 812 Style R

ALLEN-BRADLEY

Member of NEMA

Quality Motor Control whether the k.o. in the housing is the concentric type or not.

3. Some other device approved for the application.

4. Threadless connection, made up tight.

5. Double locknuts—one inside the housing and one outside the housing, with a bushing, on rigid conduit. Of the above methods, the use of double locknuts is common practice for systems over 250 volts to ground. In fact, the use of double locknuts is preferred and commonly used for light and power wiring regardless of voltage. The importance of effective grounding dictates such use. And for most effective application, the bonding

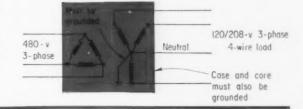
jumper method above is the surest way of obtaining sufficient conductivity and continuity through a concentric k.o. when any of the punched rings are left in place.

The core and case assembly of each transformer should be permanently and adequately grounded. Details on grounding are shown in the following illustration.

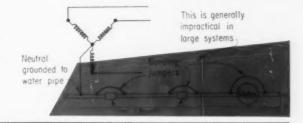
### **ELEMENTS OF TRANSFORMER GROUNDING**

1. Any system which can be grounded to operate at not more than 150 volts to ground must be grounded.

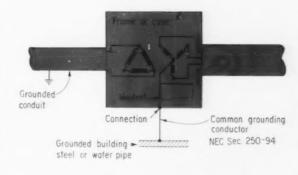
2. This requires the grounding of secondaries of dry-type transformers serving 120/208-volt, 3-phase or 120/240-volt, single-phase circuits for lighting and appliance outlets and receptacles, at load centers throughout a building.



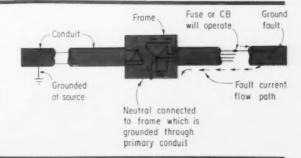
3. Grounding of the secondary neutral may be made to the nearest water pipe anywhere in the building, provided bonding jumpers are used to assure continuity of the ground path wherever the piping may be opened. [See NEC Sec. 250-112 (a).]

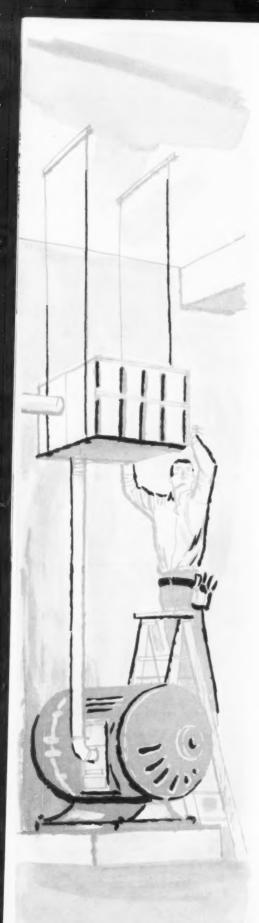


4. According to Sec. 250-54, when a system (in this case, the electrically isolated circuits from the transformer secondary) is grounded to an electrode in a building, the same electrode must be used at the same point to provide ground connection for wire enclosures and other housings, frames, enclosures, etc., even though the equipment may be grounded already through the conduit system supplying the transformer. By connecting the system neutral and the transformer frame to the same point, the ground return path for fault currents on the secondary circuit is kept short to have low enough impedance and sufficient current-carrying capacity to handle any fault currents and to assure operation of the overcurrent devices protecting the circuits, as required by Sec. 250-51 of the NE Code. If only the system neutral were connected to a local ground point-building steel or water pipe-the fault-current path for secondary grounds would be long and of high impedance. A practical solution, offering the shortest fault-current path, is to connect the neutral to the transformer housing and then make one cable connection to ground.



5. Common practice with dry-type local transformers in many installations is to merely connect the secondary neutral point to the transformer frame, leaving the feeder conduit to the transformer to provide the path to ground but depending upon the connection between neutral and frame to provide effective return for clearing faults.





# Capacitors and Regulators

EGULATION, control and adjustment of voltage and current in electrical systems involve a vast array of devices ranging from the simple resistor or rheostat to the more sophisticated combinations of transformers, reactors, capacitors and highly refined electronic circuits. Both manual and automatic operation prevail. Many of these items are inherent components of a control package (motor starters and controllers, lamp ballasts, etc.); others include individual equipments installed in a feeder or circuit to improve operating efficiency or stabilize electrical circuit or system characteristics to meet specific requirements. Capacitors and regulators fall in this latter category.

Of this group, capacitors probably are most familiar to the electrical contractor and his installation crews. Normally used to raise circuit or system power factor and reduce voltage drop, capacitors are available in units of specific kvar and voltage ratings (primary and secondary) for installation singly or in groups as required. Units come in enclosures designed for indoor, outdoor and dust-laden areas. Generally, capacitors should be in-

### **NEC INSTALLATION RULES**

### Article 460—Capacitors

Location and Protection—Capacitors in which any single unit contains more than 3 gal of combustible liquid shall be installed in a vault conforming to Part C, Article 450 (Transformer Vaults). Capacitors must have non-combustible cases and supports and shall be protected from physical damage by location, suitable fences, barriers or other enclosures (460-2 to 460-5).

Grounding and Guarding—Capacitor cases shall be grounded in accordance with Article 250. All capacitor live parts connected to circuits over 600 volts between conductors and accessible to unqualified persons, shall be enclosed or isolated (460-10, 460-11).

Disconnecting Means—A disconnecting means shall be provided in each ungrounded conductor except where capacitor is connected on the load side of a motor overcurrent device (460-8).

Hazardous Areas—Capacitors in hazardous locations shall comply with the additional requirements of Articles 550-517 (460-1).

### Article 470—Resistors and Reactors

Location and Protection—Resistors and reactors shall not be placed where exposed to physical damage; shall be of oil-immersed type or in metal enclosures where in immediate vicinity of easily ignitible material; shall be of type approved for installation conditions (see Article 500 for Hazardous Locations); shall be separated at least 1 ft from combustible material unless attached to switchboard or other non-combustible panel (470-1, 470-2).

Near Combustible Material—Units installed within 1 ft of combustible material shall be attached to non-combustible, non-absorptive panel (slate, soapstone, marble) at least ½ in. thick and supported independent of device fastenings (470-3).

Enclosure Mounting—When mounted on plain surfaces, enclosures shall make contact only at support points and maintain a minimum 1/4-in. air space between enclosure and mounting surface (470-6).

Lamps as Resistors—Incandescent lamps used as protective resistors shall be mounted in porcelain receptacles on non-combustible supports (470-8).

# C RESCENT SYNTHOL BUILDING WIRE

TYPE-THW-75° C

for WET



Type THW permits greater current carrying capacity than Type TW while retaining the advantages of smaller diameter, smooth, lubricated easy-pulling surface with solid colors. Resistant to water, acid, alkali, oil and corrosive atmosphere, it is inherently flame-retarding. It will give the lowest installed cost per ampere. Particularly advantageous for replacing overloaded feeders, as its smaller diameter makes possible greater current carrying capacity in the same size conduit.

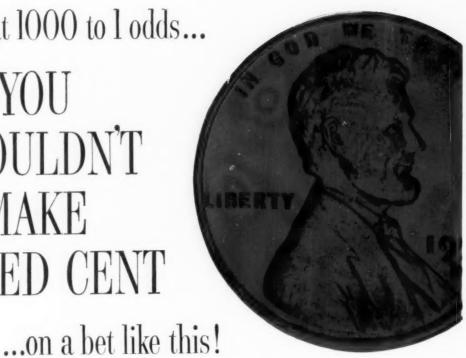


CRESCENT INSULATED WIRE & CABLE CO., INC.

OVER 75 YEARS EXPERIENCE TRENTON, NEW JERSEY

Even at 1000 to 1 odds...

# Y()UWOULDN'T MAKE A RED CENT



If you installed 1,000 G-E Fluorescent Lamps and gave us \$1 for every one that lit . . . and we gave you \$1,000 for every one that didn't . . . chances are the best you could do is break even!

Those are pretty good odds-1,000 to 1. But if this bet is ever offered to you, don't take it. You wouldn't make a red cent!

BECAUSE G-E MONEY SAVER LAMPS ARE MORE UNIFORM-Test after test of production lamps proves that, on the average, 999 out of every 1,000 G-E Fluorescents will be good, right from the start. (You might even lose money on the bet. Many users report G-E Lamp performance is even better than this!)

G-E FLUORESCENT LAMPS SAVE YOUR CUSTOMERS MONEY -Whether they buy a carton or a carload, the uniformity they get from General Electric Fluorescents-lamp after lamp after lamp—is their best assurance of getting the most light for their money. And this puts you in a very favorable light, too. Not only do they get 999 sure starters out of every 1,000 G-E Fluorescent Lamps they buy, but after almost two years 990

of these lamps will still be going strong! So they not only get more light, but their maintenance and production people like the freedom from annoyance and interruptions.

Performance like this stems from General Electric's constant search for new ways to improve all G-E Fluorescent Lamp types. Make sense? Then place your next order for lamps with your G-E Lamp distributor now-or write: General Electric Co., Large Lamp Dept. C-013, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL (28) ELECTRIC

GENERAL ELECTRIC



GENERAL ELECTRIC . . . WHERE BRIGHT IDEAS BECOME BETTER LAMPS

### WALL MOUNTING BRACKET FOR TWO, THREE, CEILING MOUNTING FLOOR MOUNTING OR FOUR LOW-VOLTAGE CAPACITORS BRACKET BRACKET Ground clamp Ground clamp 18 8 15 8 e dia. 15 % 26 18 9 dia. mtg. holes "A" 16 19 Ground clamp 18 Conduit 600-volt individualfuses, 2 per unit Backup fuse Backup Safety switch Conduit Supply conductors fuse Safety switch Supply conductors GROUP CONNECTION INDIVIDUAL CONNECTION

TYPICAL RACKS for groups of capacitor units mounted on the wall, ceiling or floor. Note clamp for grounding. Wiring

WITH GROUP PROTECTION

WITH GROUP PROTECTION diagrams show group (left) and individual (right) connections

of units with group protection of safety switch.

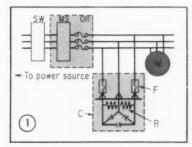
stalled as close as possible to the inductive load (at or near a motor, etc.) to attain maximum correction (from capacitor back to current source). However, they may be grouped at load-center locations. Whatever the specified location, it is the field-man's responsibility to see that they are properly mounted and have adequate mechanical protection.

Installation methods vary with

field conditions encountered. Economic consideration, floor space limitations, equipment layout and building structural features all have a bearing on whether the units are mounted on the floor, wall, or ceiling at individual loads or loadcenter areas.

Through the cooperation of manufacturers, capacitor installation has become a relatively simple chore. Cases are equipped with

sturdy mounting flanges and, when requested, standard floor brackets are furnished with individual units. Single wall and ceiling supports are available on order as are factory-designed and fabricated, multiple-unit racks for the three types of mounting. Included with these orders are all the necessary nipples, locknuts, bushings, etc., to connect the number of units involved. Factory-made racks also

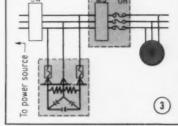


Legend: SW - Disconnect, breaker or fused switch MS - Motor starter

To power source OR - Motor overload relay

OR

F - Capacitor indicating fuses



R - Capacitor discharge resistors C - Capacitor unit

METHODS OF WIRING capacitors to induction motor circuits. Units can be connected (1) on motor side of overload relays; (2) to line side of overload relay; or (3) on the line ahead of the motor controller. In first case (1), relay should be rated to match reduced line current effected by capacitor. In (2) or (3) current through relays will not be reduced.

2

## DIAMOND PRODUCT INDEX

### DTX® Non-Metallic Sheathed Cable

It's the WHITE wire. Nonsticking, smooth and easy to pull, DTX will not flake off. Moisture and flame resistant, it is clean to handle and strips easily.

Diamond for years has concentrated on this "Basic Line" of wire and cable products . . . mixing them thoroughly with quality and prompt delivery. And remember, one source Diamond buying saves ordering time, eliminates error . . . increases your profits. All UL listed.

### **Heavy Duty Portable Cords**

Available in Red D-Prene® (red or black neoprene jacket) oil, heat and flame resistant; Black Diamond (black rubber) for general purpose use; and Signal Yellow (yellow thermoplastic) for all locations where heat is no problem.

### 600 V Building Wire Type THW

New UL listed Thermoplastic building wire for 75° wet or dry application. Small diameter, slick silicone finish. Standard colors in solid and stranded . . . sizes 14 AWG through 4/0.

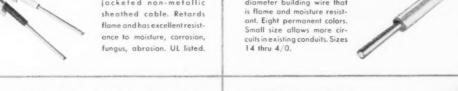


### Diamond DUF® Type UF

Thermoplastic insulated and jacketed non-metallic flame and has excellent resist-

### Thermoplastic Insulated Type TW

Diamond DTW is the small diameter building wire that is flame and moisture resist-14 thru 4/0.



### Type SE Service Entrance Cable

(Armored and Unarmored—Copper or Aluminum)

May be used without conduit from pole to building and down side of building in places not subject to mechanical injury. UL listed. Neoprene Aluminum SE also available.

### Weatherproof Wire

Triple braid weatherproof covering can be relied upon to meet severe climatic conditions. Available also with neoprene or polyethlyene insulation. Comes in solid and stranded, full range of sizes.



### **Coiled Heater Cord Set**

It's new, convenient, safer to use. Non-tangling six-foot cord retracts to 18 inches. Can be used on any heat-type appliances

### **Bare Copper Wire**

Soft drawn bare copper wire is available in a complete range of sizes, solid or 7 stranded.

### **ACT Armored Cable** & Flexible Steel Conduit

Suitable for general wiring in non-fire proof structures. Two, three, four conductor.



### Range Cord Sets

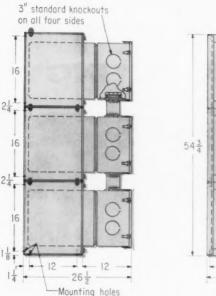
Three wire set is 36" long. Rubber molded cap, rubber jacketed cable, steel strain relief. UL listed.

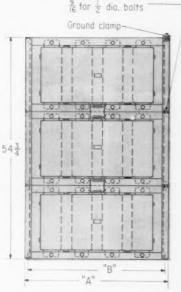


CABLE Company and

Sycamore, Illinois

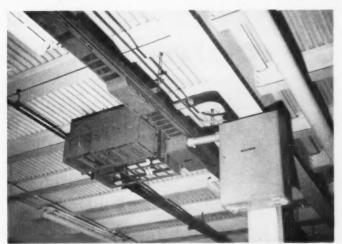
WAREHOUSES: Pittsburgh • Cleveland • Minneapolis • Denver • Dallas • Atlanta



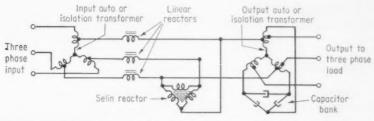


All mounting holes

TRIPLE-TIER arrangement of multiple dust-tight capacitor installation. Racks bolt together to form tiers. Dimensions vary with number of units.



**DUAL RACK** suspended from plant ceiling supports bank of capacitors fed by bus duct run. Units are not yet installed in second rack of this load-center application.



**STATIC-MAGNETIC** voltage regulator has transformer, reactor and capacitor components connected as indicated. Unit features instantaneous response to input voltage fluctuation while maintaining critical output values.

are available for outdoor, polemounted groups (primary capacitors) in straight-line, cluster or contour arrangements. A representative selection of mounting techniques is illustrated.

In general, regulation of supply voltage is a responsibility of the serving utility and is effected by installing regulators on the primary distribution circuits. Most of these units are essentially tap-changing transformers with a type of switching mechanism that automatically changes taps within a specified range as the load voltage fluctuates. Such step-regulators help maintain rated voltage at the service entrance equipment.

Of more interest to electrical contractors and engineers concerned with commercial and industrial electrical distribution systems are regulators designed to maintain constant output voltage despite input voltage fluctuations. Today, many industrial and laboratory areas, as well as data processing operations, require maintenance of critical nameplate voltages within a relatively narrow range. Among equipments for this purpose are static-magnetic regulators with instantaneous response and virtually maintenance-free design. As with any electrical device, installation should follow procedures that provide adequate mechanical protection, equipment grounding and air circulation to dissipate heat. Actual circuit connection normally involves connection of input and output conductors to terminals on the factorywired unit.

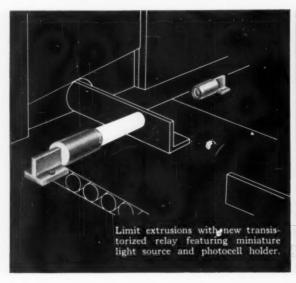


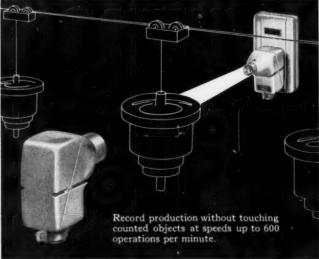
STATIC-MAGNETIC type 3-phase voltage regulator has transformer, reactor and capacitor components assembled and prewired in a sturdy metal enclosure. Unit features instantaneous response.

FOR QUALITY . . . PRODUCTIVITY . . . PROFIT . . . MODERNIZE WITH GENERAL ELECTRIC

### LIMITING

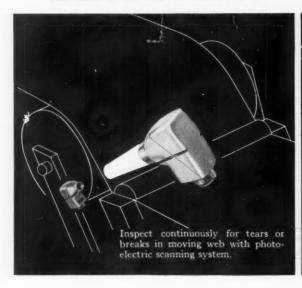
## COUNTING

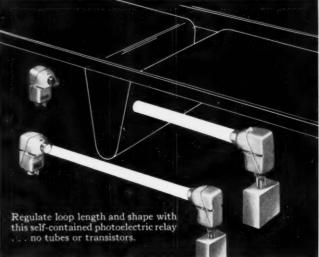




#### DETECTING

### CONTROLLING





#### A COMPLETE LINE OF GENERAL ELECTRIC CONTROL DEVICES

#### Photoelectric controls

General-purpose High-speed Long-distance

#### **Electronic devices**

Timers Resistance-sensitive relays Voltage-sensitive relays

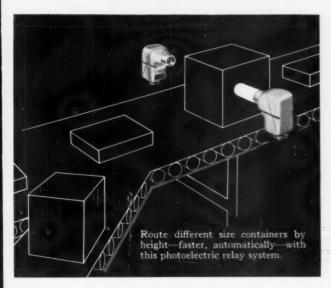
#### Photoelectric systems

Smoke-density indicators Side-register controls Cut-off register controls

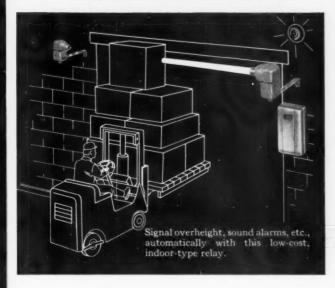
#### PHOTOELECTRIC CONTROLS



### SORTING



## SIGNALLING



Switching ... inspecting ... counting ... diverting ... sorting ... controlling. These are but a few of the hundreds of applications where General Electric photoelectric controls are helping our customers move closer to the benefits of automation—increased productivity, lower costs, higher quality.

Users are finding new ways to fit General Electric photoelectric devices into their production processes every day . . . for good reasons: These versatile G-E controls are designed for heavy-duty industrial use. They're easy to install, and require virtually no maintenance. They are highly dependable throughout a long operating life. In fact, General Electric photoelectric controls feature lamps with life expectancy of 10,000 hours—more than a year of round-the-clock operation!

#### ONE-YEAR WARRANTY, IMMEDIATE STOCK SHIPMENT

General Electric photoelectric and electronic devices carry a standard one-year warranty for your protection. And, your order for standard catalog devices is filled immediately from one of six regional warehouses. Also, replacement parts are warehouse-stocked, too, for your convenience and protection.

For expert help in applying General Electric photoelectric devices to your operations, call your nearby G-E Apparatus Sales Engineer or Distributor today. And, for your personal copy of our Photoelectric Devices catalog, mail the coupon below. General Electric Co., Speciaity Control Dept., Waynesboro, Va.

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Please send me a copy of the G-E Photoelectric Control catalog, GEA-6822, with description, specifications, and pricing data on the complete line.

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Progress Is Our Most Important Product

GENERAL ( ELECTRIC

## **Power Sources**



N ANY location where failure of normal 60-cycle utility service might jeopardize safety of life or property, an alternative power source should be provided to insure continuity of such essential operations as panic lighting, ventilation, telephone service, fire pumps, hospital respiratory equipment and stairway lighting.

#### Generators: Engine Driven

In most instances (commercial and industrial), such emergency power is furnished by engine-driven generators. Capacities of units range from a few hundred watts to several hundred kw; engines use gasoline, natural gas and diesel oil; control is obtained either manually, remotely or automatically; units are designed either as stationary or mobile power stations; and cooling is obtained either by natural convection, fan-forced air or by circulating water.

Generator engines are generally 4-cycle units having from one to six cylinders, depending upon size and capacity. Speed regulation is consistently good, and in larger sets, ignition current is supplied by starting batteries.

Installations controlled automat-

ically go into action immediately when normal-power solenoids are denergized to release spring-action contactors, or when voltage-sensitive relays are activated due to normal voltage falling below a predetermined minimum value. Automatic transfer controls generally include small trickle chargers to keep starting batteries at full potential, and time-delay relays may be included if hesitation intervals are desired between normal power failure and emergency m-g sets picking up the load.

In selecting generator sets, it should be remembered that (1) capacity should be matched to essential loading, (2) voltage and phase characteristics must coincide with those of the normal supply, (3) exhaust must be provided to the outside of the building, (4) stationary installations must be provided with permanent bases, and (5) fuel tanks must comply with code rulings and local ordinances pertaining to burial or isolation.

In some instances it is desirable to consider using more than a single generator set, thereby allowing separation of loads affected by voltage fluctuations (lighting, communications equipment and the like) from loads that fluctuate

#### **GENERATORS: NEC Article 445**

Generators should be installed in dry places with adequate ventilation and sufficient surrounding space to permit safe, effective maintenance. And, if installed in hazardous locations, specific occupancies, theatres and assembly halls, motion picture studios or the like, or if used to generate induction or dielectric heat, installation of generators must also comply with provisions of Code Articles 500, 510, 520, 530 and 665, those articles covering such items as overcurrent protection, use of explosion-proof equipment, approved enclosures, cooling, ventilation, and accessibility.

A generator must be installed with a visible nameplate showing maker's name, kw or kva rating, rpm, volts and amps corresponding to normal rating. Also, if generators are accessible to unqualified persons, live parts having more than 150 volts to ground must not be exposed to accidental contact. And, if the generator operates at a terminal voltage in excess of 150 volts to ground, the frame must either be positively grounded, or it must be completely insulated from ground.

As further defined in code construction specification sections, lead wires passing through generator frames may be protected by soft rubber bushings, provided they are not exposed to oil, grease, oily vapors, or other substances having a deleterious effect on rubber.



CHANNEL MASTER CORP.

Anderwiners Taboralories Jac.

INSPECTED

ELECTRICAL METALLIC TUBING

ISSUE NO. EN-71

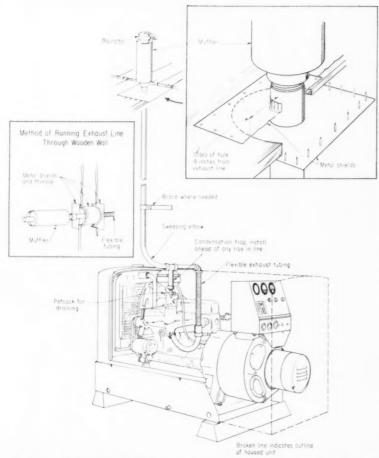
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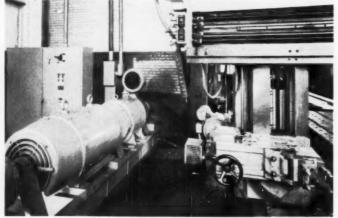
For a price below that of steel, you can have Channel Master Aluminum EMT, the lightweight tubing that stays good looking ...mirror bright, mirror smooth...inside and out. Aluminum EMT won't ever show its age.

Packaged in standard 10-foot lengths, chamfered at both ends, it is also easier to cut, bend, and put together. The hard-drawn, seamless raceway facilitates fishing and wire pulling. Standard inside and outside diameters match all U.L. approved EMT fittings.

Channel Master Aluminum EMT can be purchased through your regular distributor. Ask him to show you how to make faster, better installations at lower cost.



**TAPERED CONCRETE BLOCKS** are used to support this standby generator in order to facilitate maintenance and permit easy removal of oil pan. Exhaust pipe terminates outside building at point where hot gases or sparks will be discharged harmlessly. Since long exhaust pipes and extra fittings cause resistance to flow of gases, exhaust installation should be as short and simple as possible. If exhaust line is carried through wall, metal shields and thimble should be used to protect surrounding combustible partitions.



M-G SET consisting of ac 125-hp motor, dc 3-kw 250-volt exciter, and 225-kw generator is used to power blower-cooled main drive of double-bearing planer having 40-ft table, travel speed of 240 ft/min, and reversing cycle of 0.9-sec. Note rugged I-beam supporting frame bolted through block flooring to concrete sub-base, also adjacent control cabinet and PB station.

widely (such as reciprocating pumps and compressors, elevators, and spot-welding machines).

As to type of fuel to be specified, it is pertinent to note that gasoline engines are generally lower in first cost but higher in operation charges than diesel units. Gasoline units have good starting characteristics and acceptable ability to pick up heavy loads upon cold starting; yet gasoline storage and handling is potentially hazardous, and prolonged storage of fuel can result in its deterioration.

Gas (like gasoline) engines are low in first cost and have excellent starting characteristics and the ability to promptly carry heavy loads on cold starting. Fuel storage is avoided, although availability of large amounts of natural or manufactured gas for emergency use only is blocked frequently by utility limitations or policies.

Diesels are higher in first cost, but operation charges are less, fuel storage presents fewer problems concerning hazard and deterioration, and engines have good starting ability (when equipment is of sufficient capacity). To keep units constantly available for emergency service, it is also recommended to maintain water in engine jackets at reasonable temperatures for fast starting in cold weather (through use of immersion heating elements), and starting batteries should be kept fully charged (by chargers operating on normal power circuits). Cooling systems naturally depend upon capacities and local installation conditions, varying from the use of enginemounted radiators and fans to remote radiators and electric fans (to obtain ample cooling air when local engine-room conditions are insufficient), cooling towers and spray ponds for large units and direct connections with the building water system.

#### Generators: Motor Driven

While previous discussion emphasized use of *engine*-driven generators for stand-by emergency power purposes, it should be noted that *motor*-driven generator units are likewise used extensively for changing ac to dc, dc to ac, dc to dc at different voltages, or ac to ac at different frequencies.

Use of dc in industry should not be underestimated, for it is either necessary or preferable (for effi-

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is the transmitter tower of WGAN-TV, Portland, Maine. The 1,619 foot tower, put into full-time

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Name, type, size, number of conductors, and rated voltage are moided into the jacket by a patented Bronco process — U.S. patent Ne. 2867001.

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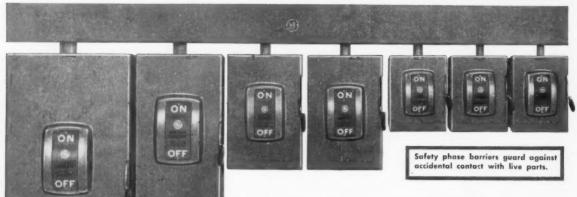
Clear ON-OFF indication from over 100 feet. Ratings plainly shown on permanent metal nameplate.



HEAVY DUTY

**▼** LIGHT DUTY

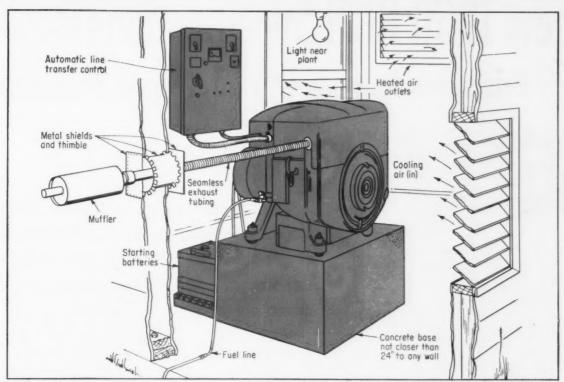
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General Electric's new safety switches bring you important savings in space, longer service life, maximum safety and more economical installation. And Heavy Duty (Type A) switches sell at Normal Duty (Type C) price levels. Write for Bulletin CPD-74, See your nearest G-E distributor for a demonstration.

GENERAL ELECTRIC

Circuit Protective Devices Dept., Plainville, Conn.



**TYPICAL INSTALLATION** of pressure-type air-cooled emergency generating plant shows mounting bolts anchored in concrete foundation to prevent settling, shifting or vibration. Special cork or rubber mounting pads are obtainable if isola-

tion of vibrations is desired to obtain quieter operation of standby unit. Note that unit is positioned with blower opposite air inlet. Battery is mounted close to generator so that lengths of connecting cables are as short as possible.

ciency reasons) for such diverse applications as electroplating, battery charging, test power, arc welding, cathodic protection, operation of magnetic brakes and solenoids, machine tools, crane and hoist motors, elevators, and for synchronous motor excitation for compressors and pumps, fans and blowers, saws and grinders.

Use of dc motors driving dc generators likewise has a spread of applications. A dc booster generator, for example, may be driven at constant speed by a shunt-wound motor to raise line voltage for the purpose of battery charging; or a 3-unit balancer may be used in single-voltage dc generator to produce a multi-voltage supply. In this latter instance, a 3-unit balancer generating 40, 80 and 120 volts could be connected to a 240-volt generator to provide six voltage steps so that related dc motors could be operated at six different speeds for various applications.

0

Frequency-changing is also coming into wider use for many special lighting installations, high-cycle induction-heating equipment, highspeed power tools, and for the operation of communication systems and special motors.

#### Rectifiers and Converters

The necessity for changing 60cycle ac to dc and the desirability of changing from one voltage or frequency to another has likewise stimulated the development of many different types of rectifiers and converters.

In this process, development of rectifiers has involved several distinct approaches, including such diverse forms as the mercury arc (ignitron), gas-filled tubes and gaseous conduction (thyratron), and various dry-disc metallic units such as those employing copper oxide, copper sulphide, germanium, selenium or, fairly recently, silicon.

Theories upon which rectifiers are based are relatively simple; for, by presenting a different resistance to the flow of an electric current whenever the direction of current is reversed, it becomes possible to effectively convert alternating current into a one-way, or direct, power source. For that reason a rectifier may be likened to a check valve,

this principle being instrumented variously by mercury-pool cathodes (in the case of ignitrons), or by electrical conductive properties inherent in the various metallic units.

That both types have important industrial contributions to offer can be illustrated by citing an installation in a large alumina-reduction plant (in Arkansas) where power requirements are in the order of 100,000 kw, and where power conversion from ac to dc is accomplished by 12 ignitron assemblies fed by 12 rectifier transformers. Each assembly consists of two 12tube ignitron rectifier groups and each group is connected through a high-speed dc cathode breaker to a common de collector bus from which a 125,000-amp potline is supplied. Normal dc is at 800 volts, although, through combinations of taps, tap changers and auto-transformers, it is possible to vary voltage from this level down to 95 volts.

Reviewing rectifiers designed on the dry metallic disc principle, it may be stated that, since they are light in weight, have no heavy moving parts and need no special foundations, their installation costs are

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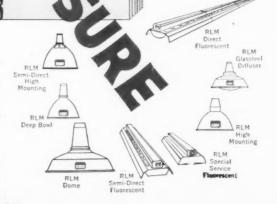
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reasonable. And, since their efficiencies are relatively high (80% or better), their operating costs are correspondingly modest. Without moving parts (except for small ventilating fan motors), their maintenance is minimum. And, due to the development of compact "packaged" units, useful floor space is conserved.

While on the subject of power that deviates from normal 60-cycle current, it should be added that (in addition to motor-generators) numerous excellent high-cycle applications are being instrumented by frequency converters. Since these units combine characteristics of a motor and generator in a single armature winding, they take up less floor space. Moreover, they are practically maintenance-free and are particularly desirable where fixed-load applications exist and/or floor space is limited.

#### Storage Batteries

Storage batteries are recommended for three basic types of application: (1) to provide power when continuous or direct connection to a normal utility source of service is impractical, such as on industrial trucks, for remote airway beacons, or for portable lighting equipment; (2) to supply an auxiliary source of power on an emergency basis when normal service is interrupted; and (3) to provide special voltage and current characteristics for such purposes as laboratory experimentation or meter calibration

Due to their reliability and wide range of applications, storage batteries are used commercially and industrially for circuit breaker control systems, control bus operation and protection, exciter power, tripping, supervisory control of power plants, emergency lighting, standby power, and as normal power sources for operating alarms and beacons, cranes and compressors, drawbridges, electroplating and laboratory equipment, public-address and sprinkler systems, telephone and teletype equipment, signalling devices, remote lighting installations, and others.

Storage batteries are available with lead-acid, nickel-iron-alkaline or nickel-cadmium cells, all operating on the same general principle but differing in characteristics. For example: alkaline-type batteries have a higher initial purchase price.

230 v control circuit

Operator's
box

Main ac contactor

TYPICAL INSTALLATION of automatic copper-oxide dc rectifier plating equipment shows fused ac supply line connected to induction-type control, supplying regulated power to rectifier. In this instance, single-phase 230-volt ac supplies power for rectifier fan and contactors, while 115-volt ac supplies power to motor-control relay and control motor. Controls in operator's box govern start-stop or raise-lower operations in tank.

Conversely, lead-acid batteries are less expensive, have slightly higher efficiencies (85-to-90% as compared with 80% for alkaline), are smaller in size, and have shorter recharging cycles.

Other factors enter into selection of batteries as well: physical use (portable or stationary); determining type of container (rubber, glass, plastic); number of cells determined by desired voltage of the installation; ampere-hour capacity depending upon current and length of discharge period; etc.

Consideration should likewise be focussed on connection of batteries. For example, cables should be flexible and long enough to relieve terminals of mechanical strain, and should be protected to prevent chafing or deterioration of insulation. If several trays are connected in series, the positive terminal of one should connect with the negative terminal of the other. Or, if connected in parallel, positive and negative terminals should be twinned together. Battery connections should be of equal size and length to obtain equal current distribution and equal wear, while batteries should be kept at the same temperature to insure equal discharge characteristics.

Maintenance procedures recommended by manufacturers should be scheduled on a regular periodic

basis. And, in addition, batteries and connections should be kept clean; approved or distilled water should be added regularly; and batteries should be kept fully charged.

Installations should conform with NEC recommendations. That is, battery rooms or compartments must be dry and ventilated in such a manner as to permit inspection and exclude dirt, oil and water. Suitable racks or stands should be provided to facilitate maintenance. Location should insure normal temperature conditions. **Batteries** should be supported firmly, level, and at equal intervals, blocked to prevent shifting, but not wedged or strapped so tightly that containers will be damaged.

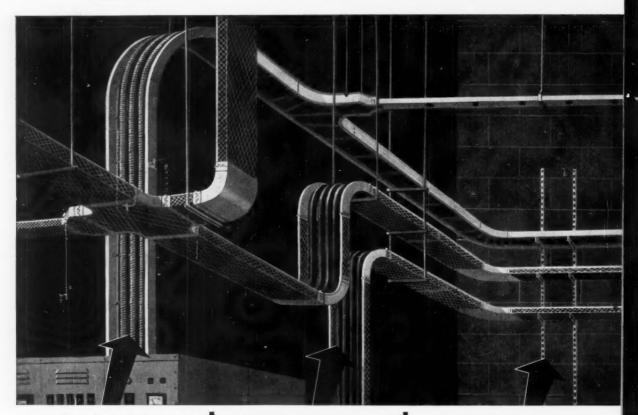
It should also be noted that two general charging methods are practiced in applications under our present consideration.

The first is manual cycling, whereby batteries are connected into a system and used until they become discharged to a predetermined extent, whereupon their recharging cycle is started manually and continued until full-charge gravity is restored. This method is used generally for mobile installations, such as industrial trucks.

The second method, referred to as floating, requires batteries to remain permanently connected to the electrical system.

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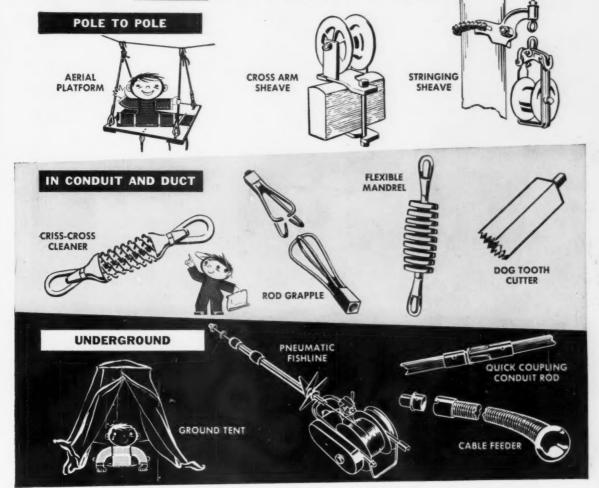


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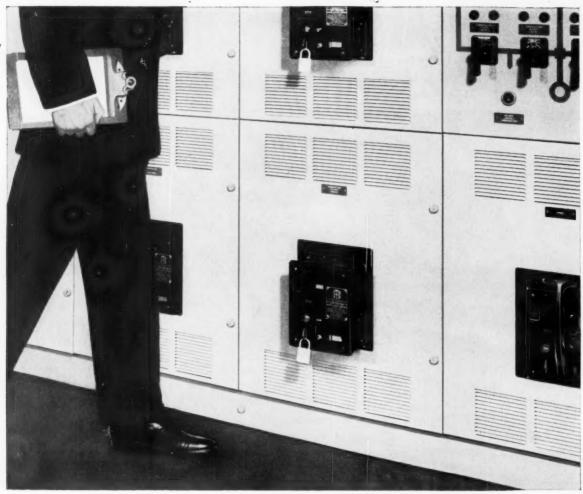
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## I-T-E CIRCUIT BREAKER COMPANY

## High Voltage

ISTRIBUTION of electric energy at voltages above 600 volts is probably the most important phase of modern electrical construction for commercial and industrial buildings. Where construction of inside wiring systems rated up to 600 volts is an old, established craft with a long and broad background of experience guiding modern application, high-voltage construction in buildings is a frontier area. It was only in relatively recent years that high-voltage distribution became a general-use technique in schools, shopping centers and all types of industrial plants. Highvoltage construction work is not steeped in traditional ways of doing things. There has been time for only a very little evolution in installation methods. The National Electrical Code is still very sketchy in its coverage of high voltage; and the Underwriter's Laboratories does not provide a guide for the use of high voltage equipment, as it does for 600-volt equipment. For all of these reasons, high voltage construction demands special and intensive consideration to assure safety, effectiveness, reliability and economy in correct proportions for each job's requirements.

Basically, the elements of modern high voltage construction can be divided into the following areas of equipment selection and installation for systems rated from 2400 volts to 15,000 volts.

1. Primary switching and protection.

2. Primary conductors and raceways.

3. High-voltage transformers and load-center unit substations.

For each of the above categories of equipment there is a wide range of types and sizes of units, with varying installation requirements. In any installation, the range of suitable devices must be narrowed down until selection is made of the device or material best suited to all of the requirements. Manufacturers' literature greatly facilitates the tasks of selection and installation. And engineering assistance is made available by the manufacturers to assure effective applica-

tion. Extreme care and research should go into each step of high-voltage construction because of the potential hazards and the substantial first cost of equipment for such systems.

Basic selection and construction data on high-voltage equipment are given in accompanying boxes on specific rules from the NEC. Other considerations are given in the following paragraphs.

#### **Switching and Protection**

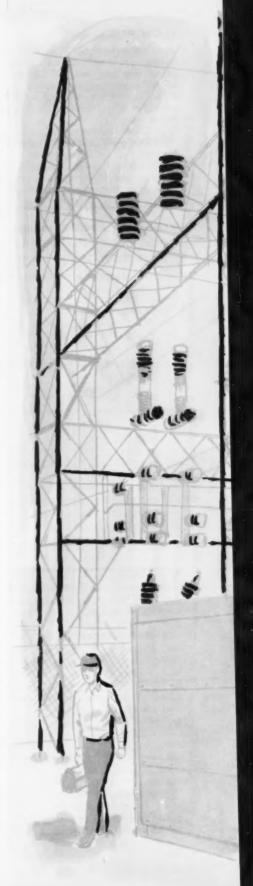
Switching and short-circuit overcurrent protection for modern highvoltage electrical systems can be provided by a number of different equipment installations. For any particular case, selection of the best arrangement depends upon: the point of application-either for outside or inside distribution or as service equipment; the voltage; the type of distribution system-radial. loop, selective, network; actual layout of the equipment; job conditions-accessibility, type of atmosphere, use; future system expansion; and economic considerations.

Modern high-voltage distribution in the range from 2300 volts up to 15,000 volts makes use of three principal devices for load switching and short-circuit protection of circuits. These are:

1. Metalclad oilless (air-break) circuit breaker switchgear,

2. Enclosed load interrupter switchgear with power fuses, and 3. Oil-fuse cutouts.

High-voltage power circuit breakers provide load switching. short-circuit protection, electrical operation, adjustable time delays of trip characteristics for seleccoordinated schemes, quick reclosing after tripping and various relay protective hookups such as differential relay protection of transformers. There are both oil type and oilless (or air-type) CBs, although the oilless type is the common type for indoor applications in systems up to 15 kv and higher. Oil CBs are generally used for outdoor applications.



#### CODE RULES ON HIGH-VOLTAGE INTERRUPTING DEVICES

#### 1. CIRCUIT BREAKERS

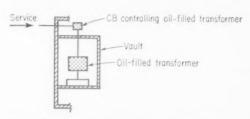
A. Indoor installations of circuit breakers must consist of metal-enclosed units or fire-resistant cell-mounted units, except that open-mounted CBs may be used in places accessible to qualified persons only.

B. A CB used to control an oil-filled transformer should (note: not a requirement) be located outside the trans-

former vault.

C. A CB must have a means of indicating the "OPEN" and "CLOSED" position of the breaker at the point or points from which it can be operated.

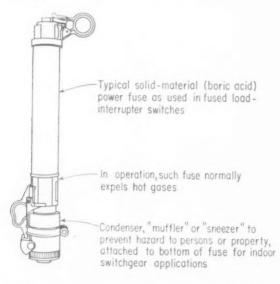
D. Oil CBs must be arranged or located so that adjacent readily combustible structures or materials are safeguarded in an approved manner. Adequate space sepa-



ration, fire-resistant barriers or enclosures, trenches containing sufficient coarse crushed stone and properly drained oil enclosures such as dikes or basins are recognized as suitable safeguards.

#### 2. FUSES AND FUSEHOLDERS

A. Fuses which expel flame in operation must be designed or arranged to prevent hazard to persons or property.



B. Fuseholders must be designed so that they can be de-energized while replacing a fuse unless the fuse and fuseholder design permits "hot" replacement by qualified persons using equipment designed for the purpose.

C. High-voltage fused cutouts installed in buildings or transformer vaults must be designed for use in such places. Where the cutout cannot be used to open the circuit under load, an approved switch or contactor capable of load-interruption must be provided. And such cutout must be interlocked with the load interrupter or be marked "DO NOT OPEN CUTOUT UNDER LOAD."

D. Cutouts must be located where they can be readily and safely operated and re-fused. Fuses must be accessible from a clear floor space.

#### 3. LOAD INTERRUPTERS

Load-interrupter switches may be used if suitable fuses or circuit breakers are applied in conjunction with them to interrupt fault currents. Such combinations of devices must be so coordinated electrically that they will safely withstand the effects of closing, carrying or interrupting all possible currents up to the short-circuit rating.

#### 4. ISOLATING MEANS

Means must be provided to completely isolate an item of equipment, to permit de-energizing for inspection and repairs. Devices which are not suitable for load interruption must be protected against load-breaking or marked to warn against such use.

above about 15 kv. Power CBs are made available in completely packaged assemblies for ready connection into the system.

Modern load-interrupter switchgear in metal safety enclosures is finding even wider application in high voltage distribution systems, in combination with modern power fuses. Such metal-enclosed fused load interrupters offer a fully effective alternative to use of power CBs, with substantial economies, in many primary voltage systems for commercial and industrial buildings. Typical applications for such switchgear parallels those of power CBs and include the following:

1. In switching centers—Switchgear is set up for control and protection of individual primary feeders to transformer load centers. Here an incoming service bay is switched to bussing from which the feeders are tapped through individual fused load interrupters.

2. In substation primaries—Load-interrupter switchgear is used for transformer switching and protection in the primary sides of substations.

3. In substation secondaries— Here the switchgear is used as a switching center closely coupled to a high-voltage transformer second-

4. In service entrances—This is a single-unit application of a switch-gear bay for service entrance disconnect and protection in a primary supply line. In many applications, more than one such assembly is

used for multiple supply circuits, often in combination with emergency automatic transfer.

Fused load-interrupter switchgear, typically rated up to 1200 amps, can match the ratings and required performance capabilities of power circuit breakers for a large percentage of applications in which either might be used. The load-interrupter switchgear does not provide as quick reclosing after fault opening as a CB because fuses have to be replaced. And it does not offer differential-relay protection of transformers against internal faults. Both of these shortcomings, however, are not generally sufficiently important in most industrial and commercial systems to warrant the substantially higher cost of CB

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Red Throat BM-21B



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BM-22 3/4" Connect



BM-23 1" Connecto



BM-No. 600 Changeable Jaw Indenter



BM-No. 1000 Handvise for ½", ¾" end 1" E. M.T.



BM-No. 100 Cutter for ½", ¾" and 1" E. M. T.



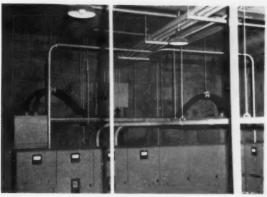
BM-No. 607 1/2" Indenter BM-No. 608 3/4" Indenter



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BRIEGEL METHOD TOOL CO.

GALVA . ILLINOIS



METALCLAD SWITCHGEAR contains a 3-pole, gang-operated disconnecting switch between each of two 4160/2400-volt service feeders (shown entering pothead enclosures at top left and right) and each of the two main power circuit breakers. Main and feeder devices are 1200-amp, carriage-mounted, drawout-type power circuit breakers with 125-volt dc electrical operation. Switchgear is mounted in basement electrical room of a large, modern, shopping center. Supply to each CB main is made by two 500MCM, 3-conductor, 5-kv



cables for multiple conductor phase feeders and two 250MCM, single-conductor 600-volt cables for a multiple grounded neutral. These cables are carried in rigid conduits underground from an outside pole. The phase wires are rubber-insulated, shielded and encased in a neoprene jacket. The neutrals are neoprene jacketed, uninsulated. Photo at right shows storage batteries for supplying the 125-volt dc for CB operation, with the floor-standing battery charger. The panel on the wall provides protection and disconnect for the dc circuits.

equipment and its installation.

Power fuses used in load-interrupter switches are available in current-limiting and non-current-limiting types. The current-limiting type is constructed with a silver-sand internal element, similar to 600-volt current-limiting fuses; and such fuses have generally



FUSED LOAD-INTERRUPTERS (one of four is shown) serve as service disconnect and protection for 4160/2400-volt supply to transformer substation in a jet aircraft hangar. Power fuses in upper section are solid material (boric acid) fuses equipped with condensers on their bottom ends to protect against gas expulsion upon operation. The bay at left contains automatic transfer-equipment to be used in conjunction with the switch shown and a second switch of the same type to be added in a third bay attached on the left of these two bays. Supply to the units is made underground in conduit, up into the cubicles.

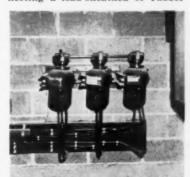
higher interrupting ratings at some voltages, but their continuous current carrying ratings are limited. They do offer reduction of thermal and magnetic stresses on fault by reducing the energy let-through.

Non-current limiting types of power fuses are made in two types of operating characteristics: expulsion type and non-expulsion type. The expulsion fuse gets its name from the fact that it expels hot gases when it operates. Such fuses should not be used indoors because of the hazard presented by the expelled gases. The boric acid fuse with a condenser or other protector against arcing and gas expulsion (such as a "muffler" or "sneezer") is a typical non-expulsion, non-current-limiting fuse.

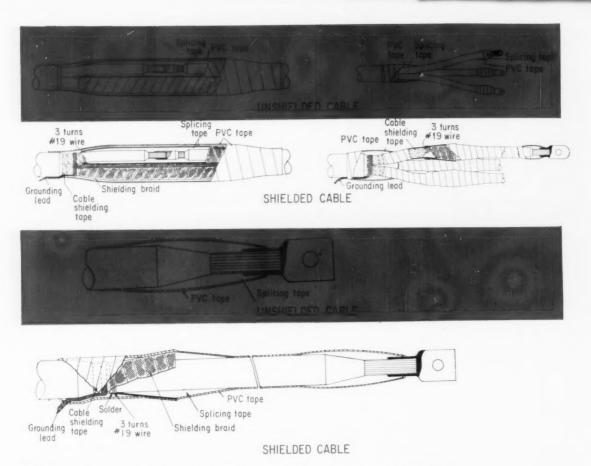
Oil-filled cutouts are also finding wide use as low-cost switching and protective mechanisms for primary electrical systems. The oil-filled cutout is a completely-enclosed, single-pole assembly with a fusible element immersed in the oil-filled housing and two terminals on the outside. The circuit is broken safely and rapidly by an internal mechanism made up of the fuse in its carrier and two contacts which the carrier bridges in the closed position. Operation is controlled at the end of the mechanism's shaft which comes out of the top of the

Oil-filled (sometimes called "oil-fuse") cutouts are made in three sizes based on continuous current rating—100, 200 and 300 amps. They are rated for use up to 8 kv.

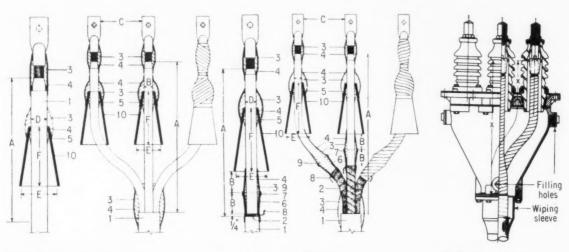
Such cutouts are made in three basic types: (1) Pole-type cutout equipped with rubber covered leads from the terminals—for use in open wiring applications; (2) Pothead cutout equipped with an insulated cable from one terminal and a sleeve on the other terminal for connecting a lead-sheathed or rubber



OIL-FILLED CUTOUTS mounted in the basement transformer room of a large suburban restaurant provide disconnect and protection for a 4160/2400-volt grounded service of three No. 4, 5-kv, unshielded, rubber-insulated, neoprenejacketed single-conductor cables run underground to the building in 3-in. fiber conduit. Each cutout is a pole-type unit, with one of its rubber-insulated leads spliced to a supply conductor and one to a conductor to the adjacent bank of three 100-kva, dry-type transformers. Each cutout is rated 5 kv, 100 amps and fused at 50 amps. IC of each is 25,000 kva, providing complete short-circuit protection for the service. The three cutouts are mounted on a gang-operating rack mechanism for switching operation by a single handle. As applied here, oil-filled cutouts provide economical and effective load-break disconnect applications with protection.



TYPICAL SPLICING and indoor termination methods for 3-conductor unshielded and shielded cables.



#### UNSHIELDED CONDUCTORS

#### 1. Neoprene jacket

2. Cable shielding
3. Nozone tape and special cement
4. Anhydrous tape and P&B paint

#### SHIELDED CONDUCTORS

5. Friction tape 6. Tinsel shielding braid 7. Binding wire 8. Ground wire

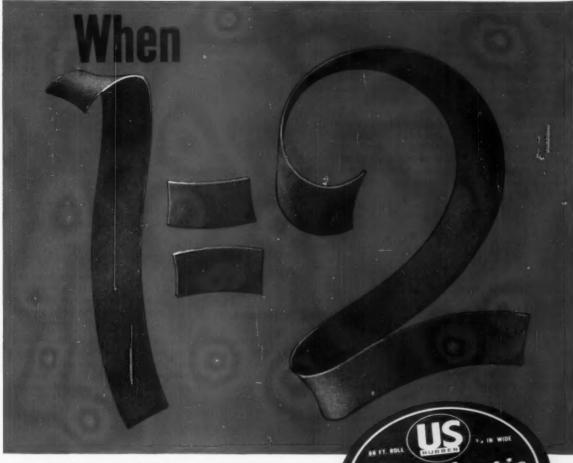
#### POTHEAD INDOOR AND OUTDOOR

9. Stress cone-thickness same

as cable insulation 10. Rubber rain shields-for outdoor terminations

TYPICAL OUTDOOR cable termination methods use rain shields on exposed conductors. Numbers indicate termination components available in special kits. Pothead enclosures are filled with compound.





## ROYALASTIC TAPE DOES TWO JOBS

It does the work of both rubber and friction tape.

- · Complete mechanical and electrical protection.
- Good tensile strength and high resistance to abrasion and to water, oils, acids, alkalies and corrosive chemicals.
- Good stretch and easy to handle. Makes a neat, thin splice. Approved by Underwriters' Laboratories, Inc.



When you think of rubber, think of your "U.S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.



Mechanical Goods Division

## United States Rubber

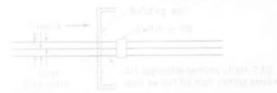
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ELECTRICAL CONSTRUCTION AND MAINTENANCE . . . MAY, 1960

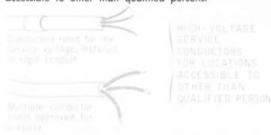
#### CODE RULES ON HIGH-VOLTAGE SERVICES



Conductors and equipment for services rated over 600 volts between conductors must basically comply with applicable sections of Article 230 on services up to 600 volts. It should be noted that, for purposes of code application, secondary conductors, not the primary conductors, are regarded as constituting the service conductors to the building proper where: (A) Step-down transformers are located outdoors; (B) Step-down transformers are located in a separate building from the one served; or (C) Step-down transformers are located in the building served, in a transformer vault meeting code rules on construction of such vaults and under sole control of the supply company.

#### 1. SERVICE ENTRANCE CONDUCTORS

A. Must be installed in rigid conduit or as multipleconductor cable approved for the purpose—in locations accessible to other than qualified persons.



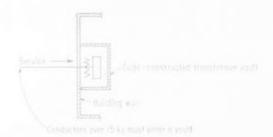
B. Where accessible to qualified persons only, open conductors may be used, mounted on approved insulators which keep conductors at least 8 in. apart, except at equipment terminals. They must be not less than 2 in. from surfaces wired over and, for voltages over 2500 volts, not less than 3 in.

C. Where cable conductors emerge from a metal sheath or raceway, the insulation of the conductors must be protected from moisture and physical damage by a pothead or other approved means.



D. Raceways embedded in masonry or in wet locations must be arranged to drain, unless conductors, specifically approved for the purpose are used.

E. Where the voltage exceeds 15,000 volts between conductors, they must enter a transformer vault meeting code rules.



covered cable from an underground circuit; (3) Subway-type cutout with a sleeve for lead or rubber cable on each terminal. For multiphase circuits, two or three cutout units can be group mounted with a gang-operating mechanism for simultaneous operation. The load-breaking capability of oil-filled cutouts and its effective fault interruption suits it to many industrial and commercial indoor applications for transformer load centers. The oil-filled cutout is often the best device for a given application.

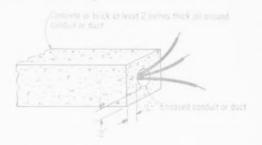
#### **Conductors and Raceway**

Primary conductors are made in many constructions for different places of use at different voltage levels. For the range of voltages up to 15 kv, the use of non-metallic sheathed cables—both shielded and non-shielded—is a definite modern trend. Such cables, in single- and multiple-conductor makeups, are used in rigid steel conduit, in underground ducts, on metal trays or directly buried in the ground. Lead-sheathed cables still find use for

underground application, especially in wet locations. Interlocked armor cable—rated at 5 kv or 15 kv, is gaining popularity for primary circuiting on cable ladder-type racks in many industrial areas.

Effective application of modern high voltage cables depends upon careful study of requirements and selection of cable. In this specialized area the manufacturers offer detailed engineering assistance. Many details on basic application are shown in accompanying illustrations covering NE Code.

F. Conductors in conduit or duct enclosed by concrete or brick not less than 2 in. thick are considered outside the building.



#### 2. WARNING SIGNS

High-voltage warning signs must be posted where unauthorized persons might contact live parts.

#### 3. DISCONNECTING MEANS

The CB or alternative overcurrent devices under item No. 5 (at right) will provide disconnecting means.

#### 4. ISOLATING SWITCHES

A. An air-break isolating switch must be used between an oil switch or an air or oil CB and the supply conductors, unless removable truck panels or metal-enclosed units are used providing disconnect of all live parts in the removed position.

B. Fuses used with non-automatic oil switches which operate as disconnects may serve as an isolating switch when they completely disconnect the oil switch and all service equipment from the source of supply.

C. Air-break isolating switches must be accessible to qualified attendants only. They must be arranged for a readily-made grounding connection on the load side.

#### 5. OVERCURRENT PROTECTION

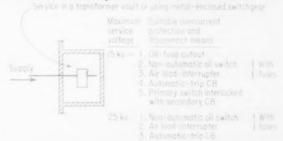
A. Where service equipment is installed in a codevault or consists of metal-enclosed switchgear, overcurrent protection and disconnect means must be provided by the following:

vided by the following:
(a) At 15,000 volts or less, oil-filled or other fuses of suitable rating and type may be used without switch or CB provided they may be operated as a disconnect.

(b) At 25,000 volts or less, a non-automatic oil switch, an air load-interrupter or other approved switch—capable of breaking rated circuit load—may be used with suitable fuses.

(c) Automatic-trip CBs may be used up to 25,000 volts.

(d) At 15,000 volts or less, a switch capable of breaking no-load current of the transformer may be used with suitable fuses if the switch is interlocked with a circuit-breaker in the transformer secondary, arranged so the switch cannot be opened when the CB is closed.



B. Where service equipment is not in a vault or metal enclosure, overcurrent protection and disconnect must be provided as follows:

(a) At 25,000 volts or less, an air load-interrupter switch or other switch capable of breaking rated load may be used with suitable fuses on a pole outside the building.

(b) At any voltage, an automatic-trip CB of suitable current-carrying and interrupting capacity, with an overcurrent unit in each ungrounded conductor and arranged that operation of any one device will open all ungrounded conductors, may be used. This CB must be located as near as possible to the entrance of the service conductors into the building or else on a pole outside the building.

C. High-voltage fuses must be rated for short-circuit duty at the point of application.

D. CBs used in high-voltage services must be free to open in case the circuit is closed on an overload. Tripfree CBs provide such operation.

One of the basic decisions to make in selecting primary cable is whether or not electrostatic shielding is required on the cable. The answer to this depends upon the type of insulation used, whether the system is grounded or not and the way in which the cable will be used. This problem should always be resolved carefully, with consultation with the cable manufacturer where necessary. The NE Code gives its minimum safety requirements on electrostatic shielding, as shown in an accompanying table.

And methods of splicing and terminating shielded cables (with and without potheads) are given by the cable manufacturers.

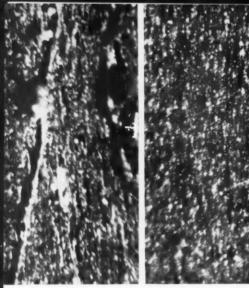
Proper termination of highvoltage cables is a very important phase of construction work. Some basic requirements are as follows:

1. Paper-insulated cables must be terminated in potheads. This requirement also extends to such cables operated under 600 volts.

2. Varnished-cambric cables should be terminated in potheads, but may be terminated with taped



LADDER RACK mounted above metalclad CB switchgear will support 15-kv interlocked armor cable feeder runs to load centers in other buildings



Above you see magnified sections of ordinary cable insulation (left) and Anaconda Butyl (AB) Cable insulation (right).



These screens, used in the extrusion head to entrap possible contaminants, are so fine they actually hold water.

## TWO BIG REASONS WHY ANACONDA BUTYL (AB)

#### 1. SPECIALIZED DEVELOPMENT

Because Anaconda was the first to develop butyl-insulated cable—and because butyl handles differently from other rubbers—many problems came up during development. Here are some examples—and how Anaconda engineers solved them.

A mixing problem: Like all raw rubbers, butyl in its raw state is a practically useless material. So it's mixed with specially selected additives and ingredients. Because it is very difficult to disperse these ingredients in butyl, Anaconda had to develop an entirely new mixing process and separate facilities to avoid contamination. Look at the comparison photos and see how successful it is.

A shielding problem: To eliminate laborious and timeconsuming cleaning of insulation surfaces, Anaconda developed a semiconducting tape\* which firmly adheres to the insulation—and yet is easy to remove during splicing and terminating.

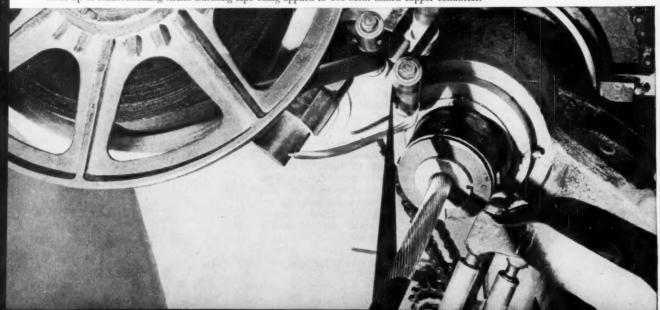
**Even a vulcanizing problem:** Ordinary vulcanizing equipment might have a tendency to deform butyl insulation. So Anaconda developed huge vulcanizing tanks which admit steam faster, vulcanize quicker and eliminate distortion.

These few examples show you the types of problems Anaconda engineers were up against. Their solutions help show you why you can be sure Anaconda Butyl (AB) Cable is the finest cable you can buy.

#### 2. SPECIALIZED MANUFACTURE

Anaconda's new Marion Mill was designed to handle only one product—Anaconda Butyl (AB) Cable.

Close-up of semiconducting strand-shielding tape being applied to 500-Mcm tinned copper conductor.





An Anaconda development-semiconducting tape-adheres firmly to insulation, yet removes easily, facilitating splicing and terminating.

## MEANS RELIABLE

## HIGH-VOLTAGE CABLE

The men behind this highly specialized equipment have but one job ... to study and improve the design and manufacture of rubber-insulated high-voltage cable. Here are a few of the many places where they built precision right into the production line.

Insulation purity: For extra protection against contamination, the unvulcanized Anaconda Butyl is passed through a series of screens, one of which is so fine it will hold water.

Strand-shield taping: For better equalization of internal electrical stress, Anaconda applies a special fine-mesh semiconducting tape under the insulation of all stranded highvoltage cables.

Vulcanizing in lead: Conventional lead presses must stop periodically for refilling-severely heating up and often damaging the cable section in the die block, so Anaconda extrudes lead continuously. In the next step, exceptionally large drums are used for vulcanizing in lead to eliminate distortion of jackets and insulation.

These few examples help show you that the manufacture of Anaconda Butyl (AB) is highly specialized, highly precise-and why Anaconda offers you the big advantage of consistent high quality.

ASK THE MAN FROM



Huge reel entering large vulcanizing tank which vulcanizes cable quicker than conventional methods, eliminating distortion of insulation.



#### CODE RULES ON HIGH-VOLTAGE CONDUCTORS

Article 710 of the NE Code covers general requirements on all circuits and equipment operated with more than 600 volts between conductors. Specific requirements on high-voltage application are covered within the articles on services, motors and controllers, transformers, capacitors, outside wiring, and other specific categories of equipment.

1. Circuit conductors must be suitable for the voltage and conditions under

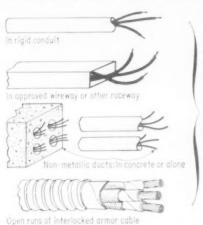
which they are installed. They must be installed:

A. In rigid conduit, or

B. In raceways or ducts, or

C. As open runs of metal armored cable suitable for the use and purpose.

D. Where accessible to qualified persons only, open runs of nonmetallic sheathed cable, bare conductors or bare bus-bars may also be used.



GENERAL WIRING
METHODS FOR
CONDUCTORS
OPERATING
AT MORE THAN
600 VOLTS —
CONDUCTORS MUST
BE SUITABLE FOR
VOLTAGE AND
CONDITIONS OF
APPLICATION

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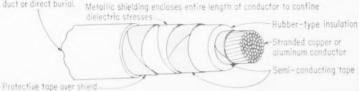
NOTE:

Article 710 does not differentiate among indoor, outdoor, overhead or underground wiring methods. Article 730, on outside wiring, requires all underground circuits to conform to Secs. 230-30 to 230-34. Sec. 310-6 covers direct-burial cables.

2. Where rubber-insulated conductors for permanent installations operate at voltages higher than those in Table 710-5 (given on the next page) they must be of a type having metallic shielding for confining their dielectric field.

Outer jacketing at tough plastic (such as polychloroprene or polyethylene) resists oils, chemicals, weather, flame, corrosive fumes, abrasion, moisture. For use in air, in conduit, in underground duct or direct burial.

Metallic shielding englases entire length of conductor to confine



3. The metallic shielding or any other static voltage shields on shielded cable must be stripped back to a safe distance according to the circuit voltage—at all terminations of the shielding, as in potheads and joints. At such points, stress reduction must be provided by such methods as the use of potheads, terminators, stress cones or similar devices. And the metallic shielding tape must be grounded.

4. Grounding of systems and equipment must conform with Article 250.

5. Where necessary, a pothead or other approved means must be used to protect the insulation of conductors against moisture or mechanical injury where such conductors emerge from a metal sheath.

connections in dry locations (or under 600 volts)

3. Rubber-insulated cables are commonly terminated in potheads, but may be terminated without potheads in accordance with manufacturer's instructions.

4. Although many modern highvoltage cables can be terminated without potheads, many engineers consider potheads the best termination for any high-voltage cable.

5. The use of potheads offers a number of advantages—



FEEDER SPLICES in 4160/2400-volt system are made in high-voltage cable boxes with potheads with wiping sleeves, as shown. Cables coming into this bank of boxes are 3-conductor, paper insulated, lead-covered, 5-kv, 300MCM in concretencased steel conduits run underground from a nearby switching center in the same basement. Cables coming from background are from the switching center. Cables from the three potheads at top feed three 3-phase transformers connected for secondary spot-network in this room.



ASKAREL TRANSFORMER steps 4160/2400-volt primary supply to 480/277-volt level. Unit is set on angle-iron runners on concrete-slab floor, behind a concrete retaining curb. Primary supply to transformer is made in rigid conduit underground. Secondary conductors are shown at top of transformer

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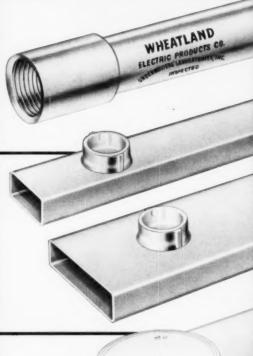
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## Table 710–5 Shielding of Rubber-Insulated Conductors

Method of Installation	Voltage in Kv (L-L) Above which Shielding is Required Neutral Grounded Neutral Ungrounded			
	Fibrous Covered	Ozone- Resistant Jacket Covering	Fibrous Covered	Ozone- Resistant Jacket Covering
In metallic conduit or trough above grade located indoors and in dry locations	16			
Single conductor	2	5*	2	3
Multi-conductor	2	5	2	5
Underground ducts and conduits and other wet locations				
Single conductor	2	3**	2	3
Multi-conductor	2	5	2	5
On insulators—	Not required under 5 kv			
Only multi-conductor			3	5
Directly in soil—				
Single conductor		3		3
Multi-conductor		5		5

"It is presumed that installation conditions will be such as to maintain a high level of jacket surface resistivity and so minimize the possibility of destructive discharge. Pulling dry or the use of insulating type pulling lubricants will help attain these conditions. Where surface contamination cannot be prevented and high surface resistivity cannot be maintained, metallic shielding shall be used at over 3 kv.

Note: Metallic sheathed single or 3-conductor cables require no metallic shielding for voltages 5 kv and less. In the case of portable equipment cables it is good practice to specify shielding for all voltages above 2 kv.

\*For three single conductor cables, cabled together without overall outer covering, the value is 5 kv.

A. Seals cable ends against moisture which would damage the insulation,

B. Provides a compartment for surrounding the termination with insulating compound to increase strength of electrical insulation.

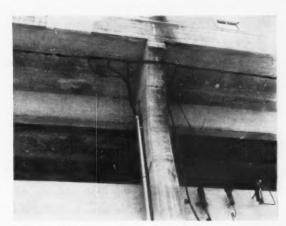
C. Seals cable ends against loss of insulating oils, and

D. Provides engineered support and connections.

6. Stress relief cones provide protection against insulation failure at the terminals of shielded high voltage cables. Manufacturers of cable and cable terminators provide special kits for preparing stress relief cones for cables operating at various high voltages.

NOTE: A POTHEAD is a cable terminal which provides sealing to the sheath of the cable for making a moisture-proof connection between the wires within the cable and those outside.

Rigid conduit is the most common raceway used for in-building distribution of high-voltage circuits. For outdoor runs or feeders between buildings, conductors are generally carried underground in rigid conduit, either directly-buried or concrete-encased, in duct, again either directly-buried or concrete encased, or as direct-burial cables. Advantages of underground installation are:



AERIAL CABLE feeder around the upper part of the wall of a sports stadium is supplied at 13,200/7,620 volts, 3-phase, 4-wire by four No. 2, 15-kv single conductor cables run-upper a wall column in 4-in. conduit from an underground run of 4-in. concrete-encased fiber conduit. The individual conductors are spliced to the aerial cable conductors. Then taps are made from the aerial cable at 12 widely-spaced points to supply single-phase, 7620-120/240-volt distribution transformers mounted on the wall. Each transformer supplies lighting panel mounted high up on a lighting tower. A typical tap layout is shown at right. The No. 2 phase conductor from the aerial cable comes into a pothead. Connection is



then made to a lightning arrester (bottom connected to ground), through a 20-amp fused distribution cutout to the transformer primary.

The single-phase primary supply to the transformer is completed by a No. 2 bare conductor tapped from the grounded neutral of the aerial cable (in upper right corner of photo at right). This conductor is used also for grounding the secondary neutral, grounding of enclosures and secondary raceway and grounding of the lightning arrester. The conductor is run to a made grounding electrode at the base of the wall. Wood-molding is used to protect the bare neutral conductor on the wall.

1. Accident hazards are reduced to a minimum.

2. Ambient temperature is lowest and cable capacities are highest.

Cables are not in the way if it is necessary to make changes above ground.

The cost of underground construction is not always justified under these conditions:

1. Unsuitable soil conditions.

2. Destructive chemical ingredients in the soil.

3. Imminent major changes in plant layout.

For underground ducts, nonmetallic conduit encased in concrete is popular. Under light traffic, with the weight of the duct line comparatively moderate, little concrete is needed and the top of the conduits need not be more than 12 to 18 in. below the surface, somewhat lower in cold climates. In stretches where traffic is heavy, it is necessary to lay the conduit deeper, possibly to reinforce the concrete with steel.

All conduit runs should be laid so they will drain throughout the run (cables are always safer in dry ducts). Never use loops and avoid vertical U-turns as much as possible. Straight runs are always preferable. Where bends are necessary make them with a long radius especially when large cable is involved. Standard bends of steel conduit are hardly ever of sufficient radius for heavy cable because they were designed for smaller wires.



DRY-TYPE TRANSFORMER BANK rated 4160/2400-volt primary and 120/208-volt secondary is mounted in a basement transformer room. Multiple-conductors are used for secondary feeder to main switch. Conductors are carried in overhead expanded metal trough. Note bushed holes where cables come through housing. Primary supply is carried along the wall to a point behind the three single-phase transformers.

#### NEC ON INSTALLATION OF LIQUID-FILLED TRANSFORMERS

#### **Mounting Askarel Transformers Indoors**

- Askarel-insulated transformers installed indoors must conform to the following:
  - A. Units rated over 25 kva must be equipped with a pressure relief vent.
  - B. Where installed in a poorly ventilated place, they must be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure relief vent must be connected to a chimney or flue which will carry such gases outside the building.
  - C. Units rated over 15 kv must be installed in a vault.



#### Mounting Oil-filled Transformers Indoors

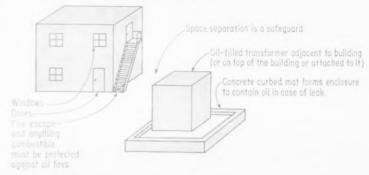
- Oil-insulated transformers installed indoors must be installed in a vault constructed according to code specs, except as follows:
  - A. Units rated not over 112½ kva may be used in vaults constructed of reinforced concrete not less than 4 in. thick.
  - B. Units not over 600 volts do not require a vault if necessary precautions are taken to prevent a transformer oil fire igniting other materials and the total transformer capacity in one location does not exceed 10 kva in combustible building construction or 75 kva in fire-resistant construction.
  - C. Units installed in detached buildings used only for providing electric service do not require a code constructed vault if no fire hazard is created and the interior is accessible only to qualified persons.



#### Mounting Oil-filled Transformers Outdoors

3. Oil-insulated transformers installed outdoors must be installed as follows: Combustible material, combustible buildings and parts of buildings, fire escapes, door and window openings must be protected from fires originating in oil-insulated transformers installed on, attached to or adjacent to a building or combustible material. Space separation, fire-resistant barriers and enclosures which will confine the oil of a ruptured transformer tank are recognized safeguards, and one or more of such safeguards must be used, according to the degree of hazard, where the transformer installation presents a fire hazard.

Oil enclosures may consist of fire-resistant dikes, curbed areas or basins or trenches filled with coarse crushed stone.



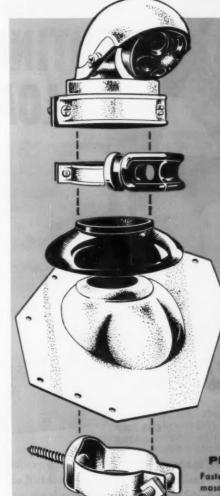
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SERVICE ENTRANCE MAST KITS

> Six Standard Kits Cover Most Installations

These Weaver Mast Kits provide everything needed for low roof service entrance installation except the conduit. All parts are designed for easy installation without tools. Six standard kits cover most installations or, on request, Weaver will pack special kits. Individual items may, of course, be ordered to meet local requirements.

Ask your Electrical Wholesaler for WEAVER Mast Kits



#### DUAL-GRIP HEAD

Clamps on pipe with two screws...no threading necessary.

#### INSULATOR

All porcelain insulator with exclusive snap-on action cuts installation time.

## STORM

Neoprene storm collar eliminates caulking... assures lifetime protection against leaks.

#### FLASH PLATE

Supports most and serves as flashing.

#### PIPE SUPPORT

Fastens conduit securely to masonry...one piece construction.

### OFFSET

Made of high-strength cast aluminum... assures positive grounding.

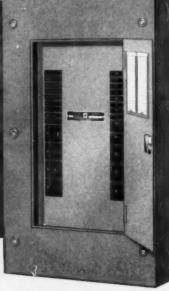
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SAVEspace time money

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NQO Panelboard

Heavy Duty Construction!

• Why waste time, space and money by installing separate lighting and power panelboards? Square D now makes it easy to combine 120 and 240 volt lighting and power loads up to 100 amperes, into one panel. Equally important, thanks to plug-in design and a complete range of circuit breakers (at right), you can get a real heavy duty industrial type panelboard with exactly the circuits you need—right out of your Square D distributor's stock\*... Write for the complete story.

through 600 AMP MAINS

\*NQO (plug-in) and NQOB (bolted connection) panelboards are also available factory-assembled for shipment direct to the job

#### FINEST BREAKER EVER BUILT!

THE QO FAMIL



QO QO -POLE 2-POLE :



Q1 Q1 POLE 3-POL 0-100 70-100 Amp Amp



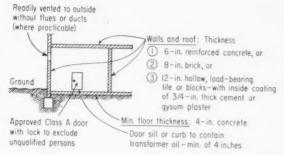
SQUARE TI COMPANY

wherever electricity is distributed and controlled

## CODE RULES ON CONSTRUCTING TRANSFORMER VAULTS

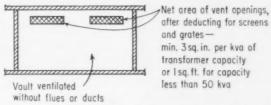
(For use with oil-filled transformers at any voltage and other transformers when rated over 15,000 volts)

 Wherever practicable, a vault must be located where it can be ventilated to the outside air without using flues or ducts.

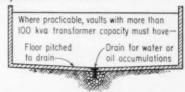


- 2. Walls and roofs of vaults must be made of reinforced concrete not less than 6 in. thick, masonry of brick not less than 8 in. thick, 12-in. load-bearing hollow tile or 12-in. load-bearing hollow concrete building units. Inside wall and roof surfaces of vaults constructed of hollow tile or hollow concrete building units must have a coating of cement or aypsum plaster not less than 34-in. thick.
- A vault must have a concrete floor not less than 4 in. thick.
- Building walls and floors which meet the above requirements may serve for the floor, roof, and/or walls of the vault.
- 5. Other forms of fire-resistive construction are also acceptable provided they have adequate structural strength for the conditions and a minimum fire resistance of two and one half hours. The inspection authority will determine the acceptability of the quality of material used in vault construction.
- 6. Each vault doorway must be provided with a tight-fitting door of a type approved for Class A openings, "NFPA Standard for Protection of Openings in Walls and Partitions Against Fire" No. 80. Doors for such openings have a fire protection rating of three hours. Such doors must be of the type approved by a recognized testing and inspection agency or be otherwise acceptable. The code-enforcing authority may require such a door on each side of the wall.

- Each doorway must have a door sill or curb of sufficient height to confine within the vault the oil from the largest transformer, but this sill must not be less than 4 in. high.
- Vault doors must be equipped with locks and must be kept locked, with access allowed only to qualified personnel. Locks and latches must permit ready and quick opening of doors from the inside of the vault.
- Ventilation in a vault must be adequate to prevent a transformer temperature in excess of that prescribed in the ASA Standard for Transformers.



- 10. Where used, vault ventilation openings must be located as far away as possible from doors, windows, fire escapes and combustible material. Section 450-45 covers arrangement, size and covering of ventilation openings and installation of dampers and ducts.
- Where practicable, a vault containing more than 100 kva of transformer capacity must be provided with a drain or other means for carrying off any accumulation of oil or water in the vault, with the floor pitched to the drain.



- 12. Non-electrical pipes or ducts should not enter a transformer vault. Piping for fire protection or for water-cooled transformers is considered part of the electrical installation. Where non-electrical piping or duct systems must be run in a vault, care should be taken to exclude from the vault devices in the piping or duct which do require regular maintenance. And care must be taken to avoid possible trouble from condensation, leaks and breaks in such piping.
- Transformer vaults must not be used as storage areas.

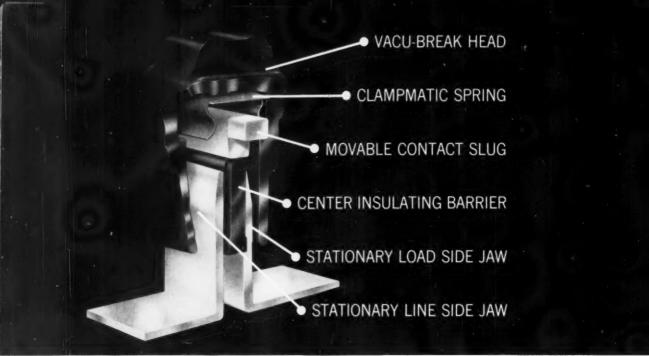
#### **Transformers**

Transformers for high-voltage systems are set and connected either as units by themselves or in combination with switching and protection in unit substations. Open and sealed dry-type transformers are commonly used for systems up to 15 kv. Oil-filled or askarel-filled units, offer advantages for outdoor application and in some indoor uses.

Installation requirements of the NE Code are shown for liquid-filled transformers and for transformer vaults. All instructions of the manufacturer should be carefully followed.

#### Table 710–38 Working Space Minimum Clear Space Adjacent to Live Parts

	Minimum Horizontal Clearance of Unguarded Parts		
Voltage Between Phases	Feet	Inches	
601	3	2	
2,300	3	3	
6,600	3	4	
11,000	3	6	
22,000	3	9	
33,000	4	0	
44,000	4	4	
66,000	4	11	
88,000	5	6	
110,000	6	1	
132,000	6	8	
Note: Interpolate for intermediate values.			



#### THE INSIDE STORY...

## Why switches last longer with clamped pressure contact and Vacu-Break arc control

This BullDog Vacu-Break® Switch Head is the reason why Vacu-Break switches stay in action longer.

See how the unique Clampmatic® spring clamps the contact slug firmly between the

line and load jaws . . . provides a virtual bolt-tight connection! This clamped pressure contact prevents overheating while in the "on" position—and as the switch moves to "off," the spring speeds the break. Both features mean longer switch life for your customers.

Equally important to longer switch life is the action of the Vacu-Break head. Arc chambers enclose the switching contacts. When contacts are broken under load, arcs are smothered quickly. Pitting and burning are cut to the absolute minimum, thereby minimizing maintenance.

BullDog Electric Products Division, I-T-E Circuit Breaker Company, Box 177, Detroit 32, Michigan. In Canada: 80 Clayson Rd., Toronto 15, Ont. Export Division: 13 East 40th St., New York 16, N. Y.

For Safety's Sake Buy Vacu-Break



BULLDOG ELECTRIC PRODUCTS DIVISION

1-T-E CIRCUIT BREAKER COMPANY



Vacu-Break switch units with clamped pressure contacts are available in BullDog Safety Switches, Switchboards, Vacu-Break Power Panels and Bus Plugs. They cost no more and give your customers the maximum in safety and performance. See your BullDog distributor.







## Signals and Communications

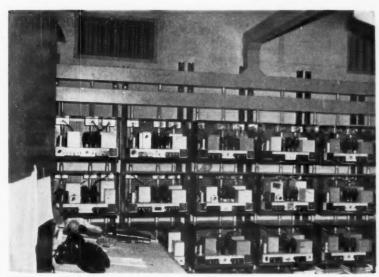
NSTALLATIONS of systems for alarms, signals and communications vary widely in methods and techniques. Many of the wiring methods involve special types of conductors, cables, boxes and connectors which are specifically made for such application. Other phases of signal wiring are generally similar to power and light wiring. Care should always be taken to follow manufacturer's instructions on wiring such equipment.

Typical circuits and systems which come under accompanying code rules include: door chimes and signals, intercom systems, sound distribution systems, fire alarm systems, television antenna systems (NEC Article 810), paging systems (lamp annunciators, coded systems, voice systems), clock and program systems, nurse-call systems (doctor's-call, etc.). It should be noted, however, that the National Fire

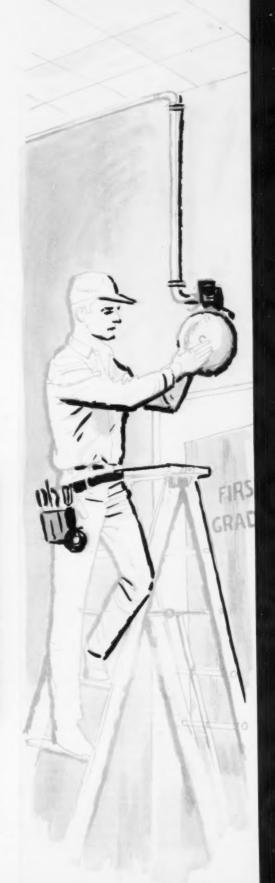
Protection Association has a special code for fire alarms—"NFPA Code 72, Standards for the Installation, Maintenance and Use of Proprietary, Auxiliary, Remote Station and Local Protective Signaling Systems, including Local or Isolated Systems for Watchman, Fire Alarm and Supervisory Service."

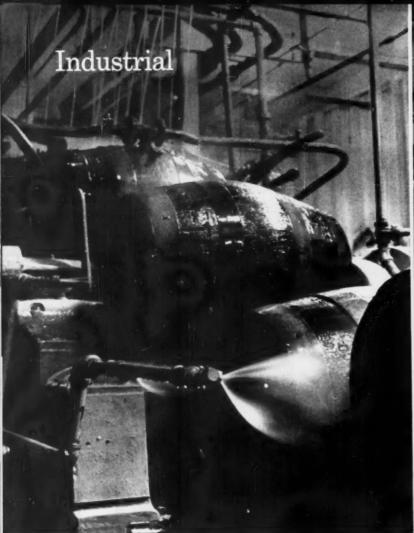
#### Input Leads

It is important to understand that most of the wires, cables and connectors employed for signal work have been specially designed and constructed for this specialized type of service and that cables and connectors commonly used in power and light wiring are generally unsatisfactory for sound work and may result in troublesome operation. For example, standard armored cable — which literally qualifies as a 2-conductor metallic-shielded



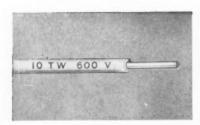
**POWER AMPLIFIERS** for a very extensive, high power sound system are racked in ventilated sheet steel enclosures on U-channel secured to the wall. The ac supply to each amplifier is made by cord and plug connection to a convenience receptacle in a handy box in each enclosure. Signal input and output circuits for each amplifier are also made by suitable separable connectors in handy boxes. The ac supplies are carried up from below in conduit. The input and output circuits are carried separately up in conduit to separate wireways for runs to microphone and other input locations and to line-matching transformers for system loudspeakers. This mounting provides ready removal of any amplifier for servicing and affords instant replacement of defective units. Signal input lines are conventional low-impedance cables, each a single twisted pair with a braided shield. Output lines are unshielded twisted pairs.







## Water and insulated wire ... do they mix?



Industrial . Rome Synthinol 901 building wire -600 volts, Type TW. Polyvinyl chloride insulation, approved by U/L for use in wet or dry locations at 60 C. Also available for appliance use at 80, 90, or 105 C, depending on wire size. Synthinol 901 was used extensively for the lowvoltage wiring in the plant shown here, for its proven resistance to moisture—in addition to its resistance to heat, oils and corrosives. These low-voltage applications include not only control circuits but also the general wiring of office and warehouse buildings and mill equipment. Also ideal for low-voltage circuits in refineries, chemical plants, other industrial plants where electrical wiring is exposed to extreme moisture or corrosives. For high-voltage industrial use, Rozone A (butyl) insulation is recommended.



Commercial • Rome's FlexAll Type UF—600 volts, nonmetallic jacket, Insulated and jacketed with Rome Synthinol polyvinyl chloride compound. In commercial applications—such as the laundry shown here—FlexAll provides positive protection against drizzling moisture, strong detergents, acids or alkalies. Cost is low. Corrosion resistance is high. Also widely used for underground between-building wiring; farm, industrial and residential yard lighting; livestock buildings and packing houses; and for breweries, cold storage and ice plants. Available in single-, two-, or three-conductor construction. Meets NEC requirements for direct-in-earth burial and interior wiring in wet or dry locations.



Residential • Rome Type SE, Style U, Service Entrance Cables can be used for long life and high weather resistance in residential applications like the one shown here. NEC recognizes the use of this wire for attachment to the side of the building from the weatherhead to meter equipment. Conductors are insulated with a heat- and moisture-resistant RHW insulation. The insulated conductors are then given an over-all covering for mechanical protection. An appropriate neutral conductor is applied concentrically over the insulated conductors and is covered with a protective weather- and moisture-resistant tape. The final covering consists of a combined pre-saturated cotton and glass yarn braid with a gray flame- and weatherresistant finish. You can paint it to match the house. Mail this coupon!





When insulated wire is exposed to water, it's not how it *looks* but how it *works* that determines its moisture resistance.

Electrical stability of the system may be seriously impaired by water that has penetrated the insulation, causing dielectric losses. *This can happen long before* you actually see any damage being done.

At Rome Cable, work constantly goes on toward developing better compounds for moisture-resistant insulations. Innumerable scientifically accelerated tests are conducted—some last from 2 to 5 years—to determine the electrical stability of new insulations.

The greater the moisture resistance of an insulation, the less electrical properties

deteriorate from long immersion in water.

The results of these tests have aided the development of the building wires shown at the left. Rome recommends them to you as ideally suited for use in industrial, commercial and residential wiring where moisture is a problem. Mail this coupon!

#### ROME CABLE

Department 7-50, Rome, New York

☐ Please send me more information on the above.

Name

Title ....

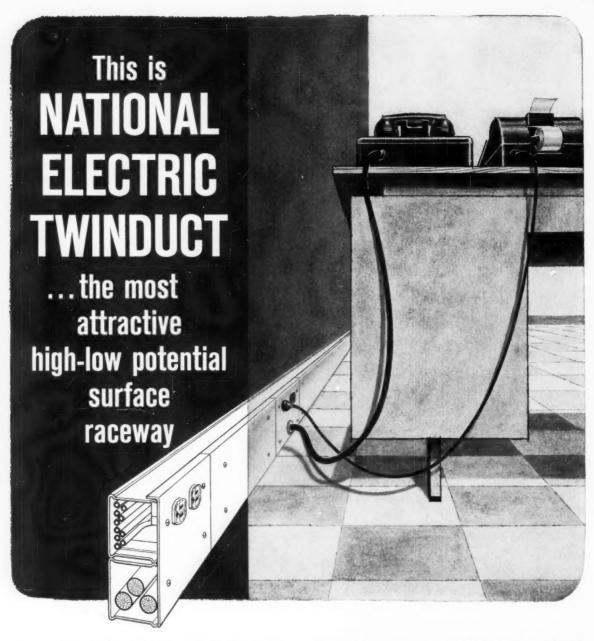
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MEET
THE
MAN
WHO'S
DEDICATED
TO YOUR JOB
YOUR
ROME CABLE
SALESMAN



Neat, modern-looking "Twinduct" Surface Raceway provides both high and low potential service under a single cover. Recessed, or surface-mounted "Twinduct" is the most attractive surface raceway for providing complete electrical services in office buildings, apartments and other commercial buildings.

"Twinduct" is not only attractive, but easy to install; offers large, unobstructed wiring areas; and has ½" and ¾" knockouts and mounting holes on

15" centers. Wires are simply "laid in," secured with twist-in steel bridges, and the cover screwed on—fast and easy installation.

"Twinduct" is but one of a complete system of National Electric "lay in" surface raceways which fit every electrical application involving loads from 15 to 60 amps. For complete information, write to National Electric Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pa.

NATIONAL ELECTRIC DIVISION



H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

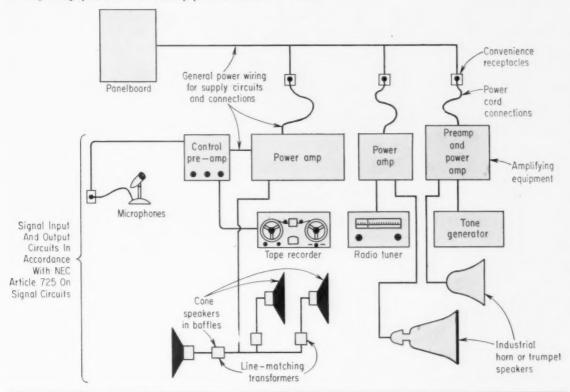
#### CODE RULES ON P. A. AND OTHER SOUND SYSTEMS

ARTICLE 640—Covers sound recording and reproduction, centralized distribution of sound, public address, speech input systems and electronic organs. Specific provisions are as follows:

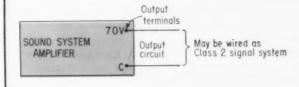
1. Power supply connections from the equipment to the building wiring system and between equipment must com-

ply with rules on general purpose power and light wiring.

2. Wiring and equipment for P.A., speech input, radio-frequency and audio frequency systems and amplifying equipment associated with radio-receiving stations in centralized distribution systems must comply with Article 725.



- 3. Wireways and auxiliary gutters may be used with conductor occupancy up to 75% of cross section area, and may be used in concealed places where run in straight lines between wiring boxes.
- Equipment must be located or protected to guard against physical damage which might create a hazard to life or property.
- 5. Amplifier output circuits rated not over 70 volts, with open circuit voltage not over 100 volts may use Class 2 wiring as set forth in Article 725.



assembly—is not electrically the same as a low impedance microphone cable which also is literally a 2-conductor metallic-shielded assembly. Microphone cables (high or low impedance) are carefully designed and constructed to insure very low capacitance per running foot so that the higher frequencies of the audio signal will not be attenuated. Microphone cables are also much more flexible than power and light cable assemblies and are far easier to handle and install.

Standard thin wall conduit is

used for running input cable. Conduit or fiber duct should be used for running cables in concrete. Where severe climatic conditions prevail or where the conduit may be exposed to dampness or corrosive conditions, care should be taken that the conduit used has the proper characteristics to protect the cable. And where necessary, conduit runs should be provided with plugs or weep outlets at low points to allow escape of moisture which might collect in the conduit.

Although rubber-covered cables

may be pulled through conduit and are widely used, cables with plastic jackets are easier to pull and therefore preferred. To simplify the job, the installer may use a standard pulling lubricant. Unfortunately, all too frequently electrical contractors will attempt to pull too many cables through a conduit with several bends and, by exerting too much force on the cables, will cause intermittent breaks and shorts which require considerable time and money to correct. Shielded cables with cotton conductor insulation

Wheeler-Fullerton and G. E. team up to produce WORLD'S BRIGHTEST RACE-TRACK LIGHTING! Home stretch at Russ Murray's Raynham Park, Raynham, Mass. (unretouched photograph)

Eight times as much light on Raynham Park's home stretch — with only a few more fixtures! That's the brilliant achievement produced by a combination of Wheeler-Fullerton's new "Q-Line" fixtures and General Electric's new "Quartzline" lamps. As a result Raynham Park is now called the best-lighted race track in the world!

Each specular "Q-Line" fixture produces a concentrated line of light, beaming the light on the desired area which is ideal for race track use. At the same time, Wheeler has engineered into the unit a long list of advancements including:

- · High efficiency
- . 50% of light beamed with as little as 6° arc
- Compact only 153/8" x 51/2" x 51/2" (1500 watt lamp)
- · Extremely lightweight
- Minimum maintenance all-aluminum construction
- · Fully adjustable mounting angle
- · Fully gasketed for all-weather protection
- G.E. "Quartzline" lamp 99% efficient over entire burning life (2,000 hrs.)

The Wheeler "Q-Line" luminaire is ideal not only for race tracks but for golf ranges, stadiums, building fronts, parking lots, outdoor signs of all kinds. Write for complete information today.



WHEELER • FULLERTON

Lighting Division — Franklin Research & Development Corp. 275 CONGRESS STREET, BOSTON 10, MASSACHUSETTS

#### CODE RULES ON SIGNAL CIRCUITS

ARTICLE 725—Covers, among other things, signal circuits. A signal circuit is defined as any electrical circuit which supplies energy to an appliance which gives a

recognizable signal. Such circuits include those for door bells, buzzers, code-calling systems, signal lights and the like.

There are two classifications of signal circuit systems:

1. Class 1 systems—those in which the power is not limited as it is for Class 2 systems.

 Class 2 systems—those in which power is limited according to maximum open-circuit voltage and maximum current rating of overcurrent protection as follows:

A. Max. 15 volts, 5 amps.

B. Max. 30 volts, 3.2 amps.C. Max. 60 volts, 1.6 amps.

(In any of the three foregoing cases, overcurrent protection may be omitted where the current supply is from a transformer or other device having energy limiting characteristics and approved for the purpose, or from primary

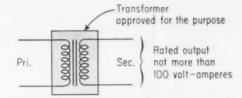
batteries.)

D. Max. 150 volts, 1 amp—provided that such circuits are equipped with current-limiting means other than over-current protection which will limit the current as a result of a fault to not more than one amp.

Properly rated max. Primary battery overcurrent protection for circuits up to 30 volts Load Open-circuit voltage not in excess of 60 volts Approved transformer Overcurrent with energy-limiting effect protection rated not over I amp Supply Load Load Open - circuit Transformer (or resistor or reactor) limits voltage between current to not more than I amp on system fault-60 and 150 volts

Overcurrent protection for Class 2 systems must be approved for the purpose.

A transformer supplying a Class 2 system must be approved for the purpose and be restricted in rated output to not more than 100-volt-amperes.



should never be used for carrying the input signals through conduit since moisture gets in easily and will almost always lead to trouble.

#### **Output Leads**

Those cables which are run from the output taps on an amplifier to system loudspeakers (either directly or through line matching transformers) are usually called "output leads." Such wiring is not usually susceptible to interference from power or signal circuits and does not ordinarily require the shielded conductors used with microphones. In some special sound installations—as in a school system where the classroom loudspeaker is often employed for intercom purposes-the loudspeaker line may have to be shielded. In the latter case a shielded single twisted pair cable may be used. In multi-channel sound systems installed in hotels and hospitals it is also standard practice to use shielded twisted pair speaker lines to prevent cross talk (transfer of a signal from one line into an adjacent line). In the majority of speaker hookups, however, an unshielded single twisted

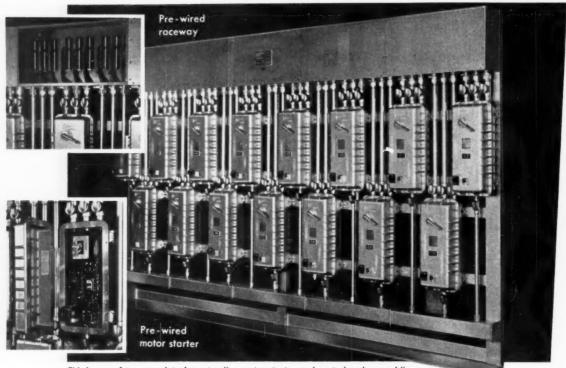
pair cable with an outer cover of cotton braid or vinyl plastic is generally used. Where cross talk is no problem, any two conductors (e.g., zip cord) will do the job.

The use of conduit for running loudspeaker wires may be either

required or recommended, depending upon the conditions which prevail. In cases where protection is needed, over and above the protection afforded by the insulation on the cable, it is recommended that conduits be used. Thin-wall conduit



TYPICAL CONSOLE for school sound system incorporates power supply, basic amplifying equipment, FM-AM radio tuner, record player and tape recorder in the drawers, complete controls, a monitor speaker and area selector switches for sound distribution to individual classrooms or other areas of the building. The complete unit is packaged in a desk-type console and located in a small, sound-conditioned room adjacent to the principal's office.



This is one of two complete free-standing motor starter and control rack assemblies recently built by Killark for a large midwest refinery. Each rack holds fifteen combination motor starters. Both racks are completely pre-wired and pre-sealed according to latest provisions for installation in hazardous locations, and are joined by a pre-fabricated wireway. Adequate flanges have been allowed for mounting.

## KILLARK CUSTOM-MADE SWITCH RACKS

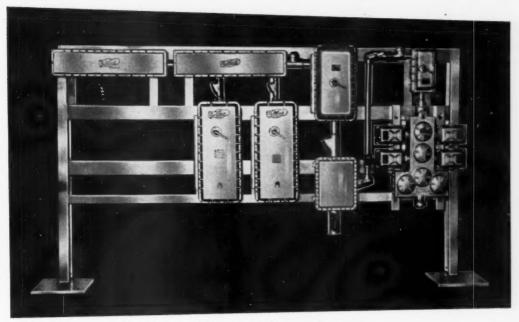
Your worries are over from the moment you choose Killark custom-made switch racks because Killark provides a complete service—design to assembly. First, Killark prepares and submits a preliminary blueprint of the entire unit, drawn to your specifications. After approval, the switch rack is assembled, wired, and sealed at the factory by Killark workers with experience and equipment to do the job right. You receive a switch rack ready to install.



Racks for indoor or outdoor, hazardous or non-hazardous areas. Write for complete literature.

ELECTRIC MANUFACTURING COMPANY

In Canada: Killark Electric of Canada Ltd. . 421 Islington Ave. South . Toronto, Ont.



The flexibility and years of experience are Killark features that can readily be seen in this custom-made rack. Notice how open rack space and an extra gutter box have been provided for expected future expansion. Killark's rust-proof, non-sparking aluminum enclosures have been used throughout the assembly.

### designed and built for your exact needs

#### CHECK THESE ADVANTAGES OF KILLARK CUSTOM-MADE RACKS:

- You get convenience because you work with one supplier, place one order, pay one price.
- You get dependable performance of Killark aluminum enclosures—circuit breakers, motor starters, disconnect switches, panel boards—all newly designed according to field tests and user surveys. Your aluminum enclosures are non-magnetic, non-corrosive, front operated. Rectangular shapes provide compact installation, easy maintenance. Components are ribbed for greater strength and faster heat dissipation which is so important to the accurate operation of thermal devices. Machined surfaces give tighter fit.
- You get the services of Killark engineers who are expert switch rack designers.
- You get a completely *integrated* unit. Components are of correct capacity.
- You get fast delivery. No delay awaiting parts from various suppliers.
- You get ease of installation. Your switch rack is ready to connect.

Next time you require a switch rack, investigate this new Killark service. You'll find that Killark custom-made switch racks can save you time, worry, and money.

#### Killark supplies everything but the current!



Now you can insure that your indoor mercury lighting installation will start and keep going even when temperatures slip far below zero. No longer is it necessary to use special, premium-priced indoor transformers or the still more costly weatherproof outdoor type for low temperature indoor installations. Sola's new standard line of indoor constant-wattage mercury lamp transformers keeps H-1, H-25, and H-33 lamps working down to minus 20°F. Two-lamp and single lamp units are both available for these input voltages: 115, 208, 230, 277, 460, and 575. They are ideal for shed, dock and warehouse installations as well as indoor remote mounting to serve outdoor mercury circuits.

These indoor transformers have new, lighter-weight core and coil construction for easier handling. Long leads and twelve knockouts in the new-designed case permit quick and easy connection. The case is liberally perforated for plenty of air circulation around the core and capacitors to give cool, trouble-free operation.

Listed by Underwriters Laboratories, the new indoor transformers incorporate the well-known Sola constant-wattage circuit which gives you these performance benefits:

Low starting current—limits current during warm-up, eliminates need for heavy wiring and time-delay relays, and permits more lamps to operate on the lighting circuit.

**Maintained light output** — holds lumen output constant within  $\pm 1\%$  for line voltage changes as great as  $\pm 13\%$ .

Open and short circuit protection — prevents transformer and wiring from overheating.

Insures rated lamp life — reduces premature lamp failure by providing stable operating conditions.

No dropout when line voltage dips eliminates lamp dropout even when voltage dips 30% from nominal.

For information, write for Bulletin MVI



BASIC PRODUCTS CORPORATION



SOLA ELECTRIC CO., 4633 W. 16th ST., CHICAGO 50

#### NEC: CLASS 1 SIGNAL SYSTEMS

 In general, wiring of Class 1 signal systems must be the same as general-purpose power and light wiring.

 Conductors are generally limited to minimum of No. 14 but No. 18 or No. 16 may be used if installed in raceway or approved cable or flexible cord and protected at not more than 20 amps.

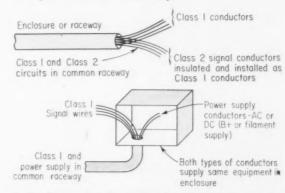
3. Wires larger than No. 16 must be Type R, T or other approved type. Fixed No. 18 or No. 16 must have insulation at least equal to type RF-2 or TF. Other conductors with specific approval for the purpose may be used. 4. The number of signal circuit conductors in a raceway may be determined from Table 1, Chapter 9.



Signal circuit conductors do not have to be derated according to number in a raceway.

6. When signal conductors are run in raceway with power and light conductors, all conductors must be derated in accordance with note 8 of Tables 310-12 through 310-15—determining the de-rating factor on the basis of the number of power and light conductors only.

7. Conductors for two or more Class 1 signal circuits may be run in the same raceway—ac and/or dc circuits—if all conductors are insulated for the maximum voltage of any conductor in the raceway.



8. Conductors must be protected against overcurrent in accordance with their current-carrying capacities from Tables 310-12 through 310-15.

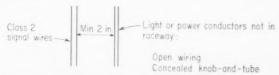
#### NEC: CLASS 2 SIGNAL SYSTEMS

1. Conductors and equipment on the line side of devices supplying Class 2 systems must conform to rules for general power and light wiring.

 Class 2 conductors must be insulated and must be separated from conductors of electric light and power circuits as follows:

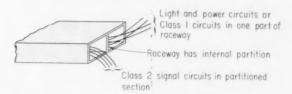


A. Open conductors must be separated at least 2 in. from power and light conductors not in a raceway, unless separated by a continuous and firmly-fixed non-conductor.



B. Class 2 conductors must not be used in any raceway, compartment, outlet box or similar fitting with light and power conductor or with Class 1 signal or control conductors, unless the conductors of the different systems

are separated by a partition. But this does not apply to wires in outlet boxes or similar fittings or devices where power supply conductors are introduced solely for supplying power to the signal equipment to which the other conductors in the enclosure are connected.



C. In shafts, conductors must be separated at least 2 infrom power and light conductors or the conductors of either system must be encased in non-combustible tubing.

D. In hoistways, conductors must be installed in rigid conduit or EMT, except as provided for elevators in Article 620.

E. Conductors run vertically in a shaft or partition must have fire-resistant covering capable of preventing the carrying of fire from floor to floor except where conductors are encased in non-combustible material or located in a fireproof shaft with fire stops at each floor.

is usually satisfactory but heavy wall conduit is indicated where severe climatic or corrosive atmospheric conditions prevail. Infrequently, lead-covered cable is used in extremely damp locations (i.e., speaker lines run underground) to provide maximum protection. Loudspeaker cables may be run in ventilation or air ducts or closely fitted to wall molding. Connections at the loudspeaker end (at line matching transformer) are made by soldering to lugs.

#### **General Installation Tips**

 Never use acid core solder. Resin core solder is recommended.

2. Do not attempt to force too many cables through a conduit.

3. Always ground amplifier, console or cabinet rack.

4. Do not run speaker and microphone lines in the same conduit. Never run either of these in the same conduit with power cables.

5. Label speaker cables before pulling through conduits for easy

identification of each twisted pair.

Do not use ac-type plug outlets where specially designed microphone connectors are indicated.

7. When splicing shielded cable, make certain that shield is continuous and soldered at the joints.

8. When soldering conductors with vinyl insulation (to connectors or lugs) avoid excessive heat.

9. When loudspeaker cables are run over very great distances, carefully determine required copper diameter of conductor.



Edward Goldkuhl, owner; Don Hartman, Westinghouse sales engineer; Fred Bertetta, owner; Spence Pors, Westinghouse Electric Supply Company sales representative. To the right, one of 40 Westinghouse EP dry-type transformers serving over 350 trailers.



Treasure Island Trailer Court occupies 17% acres at Colma, California, 15 minutes from San Francisco. In addition to basic service to 350 mobile homes, the new distribution system powers 3 laundries and 171 street lights within the area.

## TRANSFORMER SILENCE IS GOLDEN AT TREASURE ISLAND TRAILER COURT

"Westinghouse dry-type transformers virtually eliminate noise, fire hazard," states owner Fred Bertetta

## TREASURE ISLAND TRAILER COURT

"We chose the Westinghouse dry-type EP transformers for several important reasons," continues Mr. Bertetta. "The continual hum characteristic of ordinary transformers would be extremely irritating when

placed as close to living quarters as these, in a trailer camp, have to be. Westinghouse has almost completely eliminated noise . . . you can't hear a thing, even when you put your ear right up against the equipment.

"Second, Westinghouse dry-type units—and there are 40 of them here—don't present a fire hazard. Where people are living close together, that's especially important. Third, the ease of installation and the service Westinghouse provides influenced our decision. We've had trouble-free equipment since the system was installed in 1957... yet we know we could have a replacement transformer within the hour, day or night, by calling the Westinghouse sales representative here."

Just outside San Francisco, Treasure Island Trailer Court provides space for 356 mobile homes. Power requirements for each home have grown five times since the Court's establishment in 1948. Electric heating, stoves, washers, air conditioning, additional lighting now demand 35-ampere, 120/240-volt, three-wire service. 480-volt primary current is now brought directly to 40 locations and stepped down with Westinghouse 10-kva EP transformers. All expenses paid—installation and maintenance costs paid in advance by reduced power rates realized in purchasing power at 480 v—vs—120/240 v. Plus continued savings with improved regulation—improved service.

Westinghouse dry-type transformers are performing similar services in modern commercial and industrial applications everywhere, and doing it efficiently, safely, quietly . . . quietly . . . quietly . . . quietly. Perhaps they can serve you—find out from your Westinghouse representative. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-70940

#### YOU CAN BE SURE ... IF IT'S Westinghouse

WESTINGHOUSE DS-3 TRANSFORMERS-JUST A WHISPER AWAY FROM SILENCE

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS-TV ALTERNATE FRIDAYS



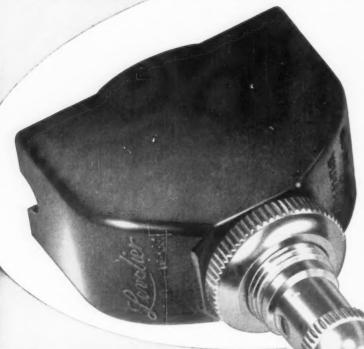


Three DS-3 480-volt to 120/240-volt dry-type transformers. Mr. Hartman points out that this unit operates at a sound level below 45 decibels—at least 15 decibels below NEMA standards. One important reason is that the corecoil assembly floats on a built-in mechanical vibration damping system, independent of case, base and connect-

ing conduit. Beyond that, only Westinghouse sound level tests all dry-type transformers. *Only* Westinghouse performs these vital tests at an ambient of 24 decibels. Maximum temperature rise—case, 35°C. Terminal compartment, 5°C above ambient.

### Specify McGILL Levolier switches

... for guaranteed precision plus durability



The high standards of design, craftsmanship and material selection make it possible to guarantee No. 41 LEVOLIER switch unconditionally against failure in lighting circuits. This extra quality is reflected in the performance of all LEVOLIER switches.

It pays to specify the best to avoid frequent and costly replacement. LEVOLIER canopy, toggle, push button and momentary contact switches are recognized for their reliability and long life.

All are Underwriters' Laboratories inspected.

UNCONDITIONALLY GUARANTEED No. 41 single-pole, single-circuit, universal lever switch 6 amp. "T" amp. 250V. Only 5/8" thick, it is ideal for conduit box and canopy mounting for lighting and FHP motor control.



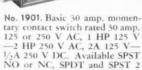
No. 100 single-pole, 15 amp. 125-250V, 1 HP 120-240V AC, normally "OFF" momentary contact switch. 1 amp., 125V-1/2 amp., 250V DC. Especially suitable for limit and safety control of industrial machinery.



No. 25 toggle switch carries a 6 amp. "T" 125V, 3 amp., 250V rating with an S.P.S.T. double-break mechanism. 1/3 HP AC 120-240V. Ideal for panel board, FHP motors, appliances, power tools, etc.



No. 90 3/4 HP capacity, 15 amp. 125V, 10 amp. 250V toggle switch with an S.P.S.T. mechanism. Designed for AC operation. Also carries 20 amp. 125V AC non-inductive load for heater applications. Also available in two circuit with center off and no off. Choice of terminals.



No. 1901. Basic 30 amp. momentary contact switch rated 30 amp. 125 or 250 V AC, 1 HP 125 V —2 HP 250 V AC, 2A 125 V—1/2A 250 V DC. Available SPST NO or NC, SPDT and SPST 2 ckt. with six standard actuators. Size 1.876" x .812" x .500".

No. 71 single-pole, single circuit, universal lever switch . . . the thinnest 6 amp. "T" 125V—3 amp. 250V switch of its kind on the market today - only 15/32" thick. Also with push button.

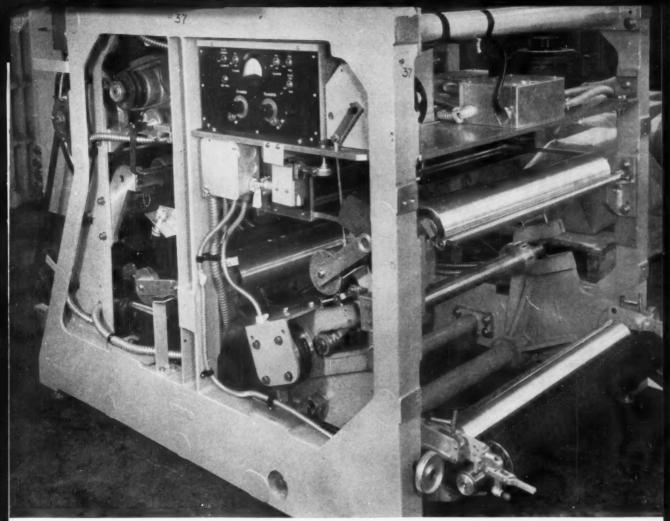
For complete descriptions of the entire McGILL line of switches, sockets, portable lampguards and other electrical specialties, write for catalog No. 84.

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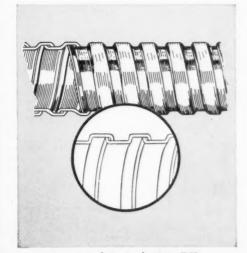


McGILL MANUFACTURING COMPANY, INC., ELECTRICAL DIV., 450 N. CAMPBELL ST., VALPARAISO, INDIANA



XeroX\* Copyflo\* Continuous Printer with panels removed shows compact wiring installation possible with Anaconda Type DSL conduit.

#### TURN TIGHT CORNERS EASILY WITH ANACONDA TYPE DSL EXTRA FLEXIBLE WIRING CONDUIT



Cross section of Anaconda Type DSL conduit. Made from galvanized steel, without packing; extra flexible construction.

The compactness of modern design calls for Anaconda Type DSL extra flexible wiring conduit—made especially for jobs where small bends are required. For example, look at the interior of the XeroX Copyflo continuous printer shown above—a great deal of wiring, enclosed in DSL, was snaked around in relatively tight quarters.

Anaconda Type DSL is high-quality conduit made of galvanized steel—without packing, for more flexibility. It comes in a full range of sizes— $\frac{3}{16}$ " I.D. through  $\frac{3}{4}$ " I.D.—in convenient standard length coils. For complete information and specifications contact your electrical wholesale supply house or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn.

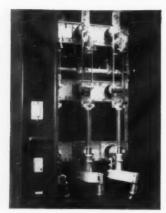
\*Registered trademarks of Haloid Xerox Inc., Rochester, N. Y.



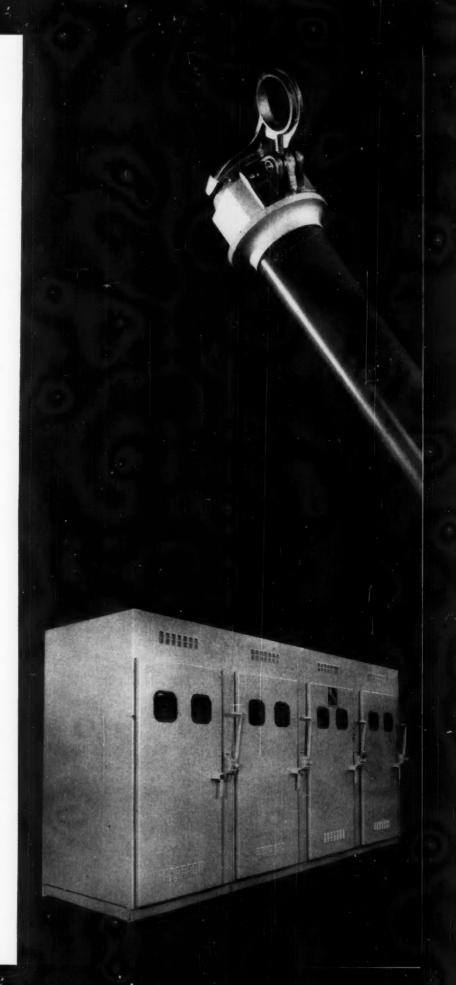
extra flexible wiring conduit

an ANACONDA® product

## SEES ALL YOUR FAULTS



Inside view of typical bay, showing load interrupter (for switching), power fuses, and out-going pothead.





## A Power Fuse both senses and clears short circuits—cuts cost of metalclad switchgear 50%

With S&C Metalclad Switchgear you get dependable protection for your high-voltage power circuits at about half the cost. How? Partly through the use of S&C Power Fuses instead of circuit breakers and relaying.

The power fuse is self-sufficient. It needs no instrument transformers, no relay. There is nothing to set, adjust, test, or maintain. You don't need special equipment or skills. After the fuse clears the fault and the cause has been corrected, you simply reach for a \$13.50 refill stored in the compartment door.

Power fuses give you the protection you need against permanent destructive faults. Industrial and commercial high-voltage power circuits are not subject to transient faults (such as lightning, falling trees, wind, ice, rodents) and so don't need the automatic reclosing feature of the circuit breaker.

S&C fused interrupter gear meets the new National Electrical Code requirements for fault closing. It is available in short circuit interrupting ratings up to 500 mva at 14.4 kv, 250 mva at 4.16 kv. Continuous current ratings are 200, 400, and 720 amperes. Maximum capacity of main bus, 2000 amperes.

#### **S&C ELECTRIC COMPANY**

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#### WIREMOLD SURFACE METAL RACEWAYS

THE WIREMOLD COMPANY . DEPT. EP9, HARTFORD 10, CONNECTICUT

#### PLUGMOLD® Multi-Outlet Systems

Cover a wide range of electrical outlet requirements - for new construction or rewiring jobs. Mount on any surface. walls, work benches, counters, displays, etc. A minimum of fittings is required.





Furnished three ways: unwired (space outlets as desired); factory-wired sections (for short runs); and prewired Snapicail (outlets on various centers).





One size raceway accepts three types of outlets—2-wire NEMA grounded and 2- and 3-wire duplex. Furnished either as pre-wired Snapicoil (outlets 30" or 60" on centers), or factory-wired sections with closer spaced outlets (for short runs).





Furnished unwired (space outlets as desired). Receptacles available include 2-wire, 2- and 3-wire grounded, lumiline single, midget twistlock, 3-wire polarized, 3-wire polarized grounded, and T-slot.





A combination multi-outlet system, wiring raceway and steel baseboard. Same receptacles as No. 2000. Furnished as pre-wired Snapicoil (same as No. 2000).



Any standard device designed for a single gang box can be installed wherever needed within the raceway. Standard flush plates are used.

CAPACITY (for wire types T. TW. RU)

PLUGMOLD		NO.	NO.		NO. 12	NO 14
NO. 1900	with devices no devices	=	=		3	3
NO. 2000	with devices no devices	=	=	-	3	3
NO. 2100	with devices; co	nsult Wi	emold 8	Catalog   10	No. 2	1 10
NO. 2200	with devices no devices	3 5	7 8	10 10	10 10	10 10
NO. 3000	with devices no devices	8 10	10	10	10	10

#### WIREMOLD® Surface Wiring Raceways



Used along ceilings and walls - to modernize existing wiring, or complete new wiring from panel box to outlets. A minimum of fittings is needed. Four sizes; furnished as onepiece raceways.

NO.200

NO.500

NO.700

NO.1000



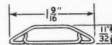
CAPACITY (for wire types T, TW, RU)

WIREMOLD		TOR SIZE	NO. 10	NO. 12	NO. 14
NO. 200	-	-	-	3	3
NO. 500	-	2	3	4	5
NO. 700	-	3	5	6	8
NO. 1000	5	8	8	10	10

#### PANCAKE® Overfloor Duct Systems

Strong, flat overfloor raceways to carry power and light and communications wiring to locations away from walls. Quickly installed without channeling into floors. A minimum of fit-





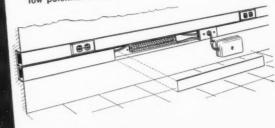
CONDUCTOR SIZE:	NO. 8	NO. 10	NO. 12	NO. 14
wire types T, TW, RU	4	4	6	8

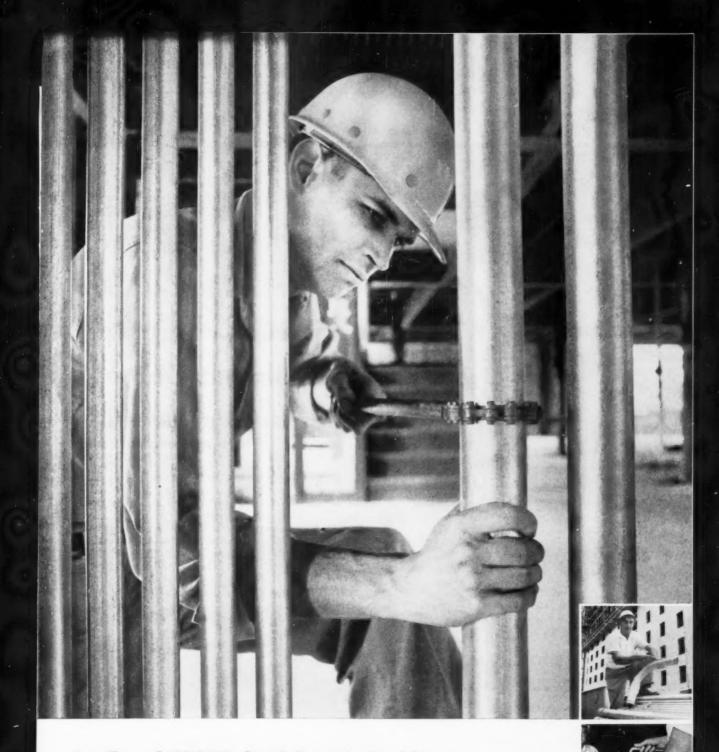
NO.2600 (not shown)

CAPACITY: two 26-pair telephone cables.

#### **TELE-POWER Duct Systems**

Consist of a pair of parallel Plugmold Raceways one for telephone, signal and inter-office communications wiring; the other a multi-outlet system for power and light wiring. Because each raceway has a separate cover, the electrical contractor or telephone installer needs only install or remove the cover for the wiring that concerns him. The high and low potential wiring are not exposed to each other.





**9 miles of SPANG Conduit protect wiring** in the new Plaza Apartments, Wilmington, Del. Benjamin J. Lener, general foreman, Light & Power Construction Co., reports Spang uniformity provided a good job, saved installation time, protects his company's reputation. Uniformity of Spang Conduit meant consistently good bends and fast, accurate threading on the job. Smooth interior finish provided easy wire pulling, prevented wire damage. The HD Galvanized finish has high corrosion resistance, didn't flake or chip during bending. You'll get top-quality jobs with Spang, too. See your local Spang Distributor for fast service!

Architect: Victorine & Samuel Homsey, Wilmington General Contractor: Ernest di Sabatine & Sons, Inc., Wilmington Electrical Engineer: Everett Miller, Philladelphia Electrical Contractor: Light & Power Construction Co., Elsmere, Del. Spang Distributor: Westinghouse Electric Supply Company, Wilmington



THE NATIONAL SUPPLY COMPANY

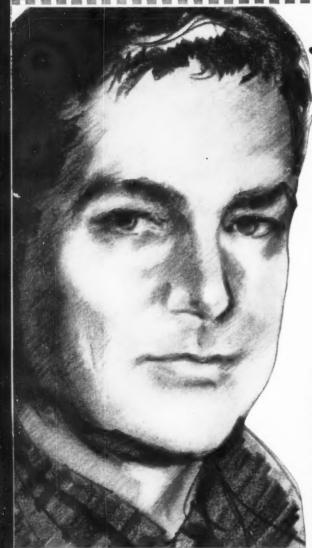
Two Gateway Center, Pittsburgh 22, Pennsylvania Subsidiary of Armco Steel Corporation





#### JOB-PROFIT TOOLING IDEAS

FROM GREENLEE



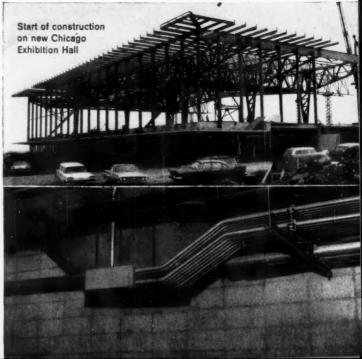
"We saved an average of 65% per bend for material and labor compared with using fabricated elbows"

says Mr. George Koslowski, supt.
FISCHBACH, MOORE AND MORRISSEY
CONTRACTORS

"Nearly all of our conduit-bending and metal-punching operations are done with Greenlee tools," says George Koslowski, superintendent for Fischbach, Moore and Morrissey, nationally known electrical contractors. "On this job, the new Exhibition Hall on Chicago's lake front, we have found that these tools get the jobs done faster — at an average labor and material savings of 65% on every bend compared with using manufactured elbows."

Specifications for this job called for more than 400 offsets and 1000 separate bends in conduit ranging in size from  $1\frac{1}{2}$ " - 4" in diameter. A typical conduit installation is shown at right.

Reliability, fast setup, and interchangeable components were important timesaving advantages of Greenlee tools. Job-Profit Tooling Ideas using Greenlee hydraulic benders, knockout punches, and power pumps are shown on facing page.





Offsets in one shot, one setting. Three offsets are now made in the time formerly needed for one. To speed offset bending on the Chicago Exhibition Hall job, Fischbach, Moore and Morrissey men used two Greenlee No. 888 multipurpose hydraulic benders (for ½" - 2" conduit) powered by Greenlee No. 798 AC-PO power pumps. Offsets are always in correct alignment — no doglegs.

Bending big conduit is faster, too, with a lightweight Greenlee No. 884 hydraulic bender. Two of these were used on this job to make one-shot bends in all sizes of conduit up to 4".



Other Greenlee lightweight hydraulic benders are available in ½" - 2" and ½" - 3" capacities for aluminum or steel conduit. Attachments for bending thin-wall conduit, bus bars, and tubing also available.



Knockouts in one shot! Pre-drilling and step-up punching are entirely eliminated with a Greenlee No. 1732 hydraulic knockout punch driver. As many as four operations saved on larger holes. Superintendent on the job reports that setup time averaged eight minutes for 4" knockout holes in 12-gauge material. Holes were punched in seconds. This driver powered with a Greenlee No. 798 AC-PO pump saved from 1½ to 2 hours over the time that

would be needed with conventional punches and hand pump.

To punch smaller holes, this contractor put Greenlee No. 1804 ratchet knockout punch drivers on the job. Operation is six to eight times faster than wrench method. Standard Greenlee punches ½"-3" are easily driven by this tool.

The Greenlee line includes a complete range of knockout punches for ½"-5" conduit. Available singly or in handy sets with carrying cases.



Idea for faster bending and punching. Greenlee power pumps proved a big time-and moneysaver for George Koslowski and his crew. The Greenlee No. 798 series power pumps they use provide from three to five times faster operation of their benders and hydraulic knockout punch drivers. Quick couplers on all units make interchanging pumps fast and easy.

Exclusive Greenlee feature of twospeed action... fast approach and automatic changeover to lower speed, high-pressure drive means savings on every job. Greenlee makes a complete line of power pumps to drive hydraulic equipment in the shop or on the job.

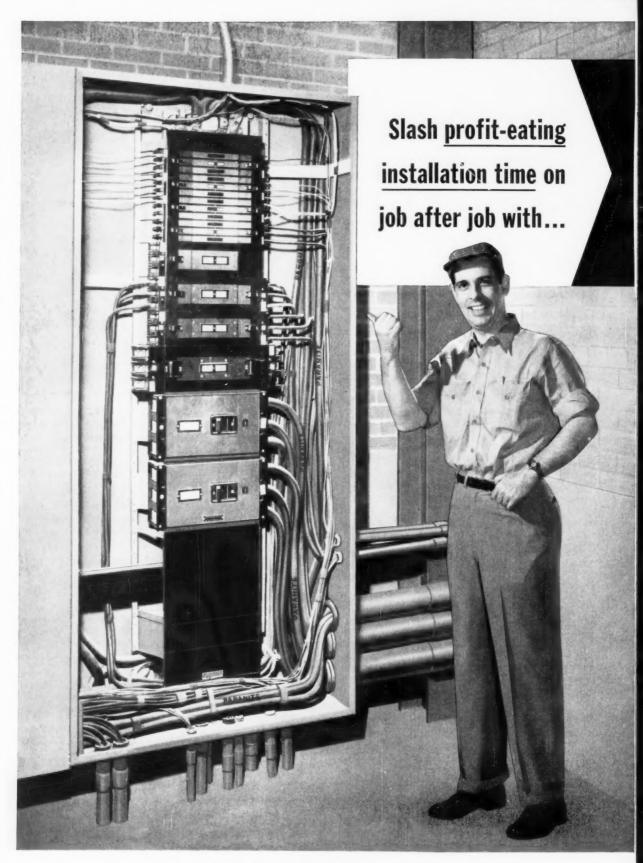
To learn more about GREENLEE JOB-PROFIT TOOLING ask your wholesaler for a demonstration or write for our new, fully illustrated quick-reference bulletin E-240.

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## PROFIT PACER PAIR AND DE

BUILDING WIRES AND CABLE

Time is your most costly commodity! That's why Paranite concentrates on the production of quality wire products that stretch every man-hour to its utmost efficiency. The result is a more profitable operation for the contractor using Paranite products. From sheath to core—every possible time-cutting feature has been built-in to minimize loss of time. Paranite strips fast—slick finishes assure smooth pulling. Dead-soft conductors give superior flexibility to speed-up working through studs or in conduit. And finally, Paranite wire products are in labor-saving packages with color-coded labels for instant identification. Yet you pay no more for Paranite!

A. Paranite Parasyn® Type TW 600 V small diameter building wire is thermoplastic insulated for use at temparatures up to 60°C. It is flame, moisture and oil resistant. Standard colors available from stock in both solid and stranded, sizes 14 AWG through 1000 MCM. UL listed.

B. Parasyn® Type THW Thermoplastic insulated 600 V building wire is UL listed 75°C for wet or dry application. Small diameter, slick silicone finish color availability and stripping ease assure reduced handling costs. Solid and stranded, 14 AWG through 500 MCM.

Paranite wire products are readily available from leading distributors across the nation in a full range of sizes and conductors, both copper and aluminum.

# AJO PARAWITE PARASYN TYPE TW





ESSEX WIRE CORPORATION, Marion, Indiana

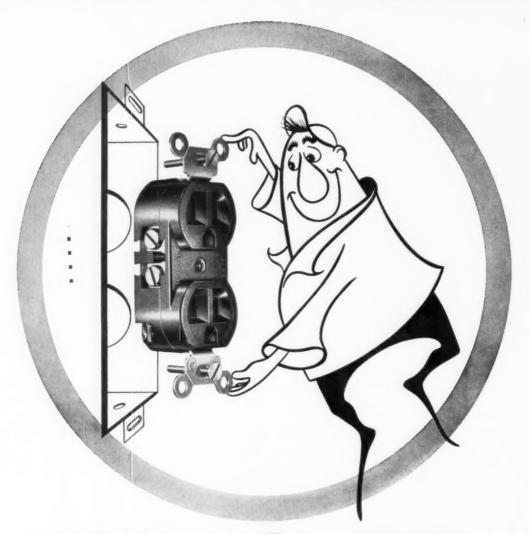
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fast installation is another big feature of RODALE devices

Back wiring on these duplex receptacles and one inch depth measurement on the TOUCHETTE switch are two of the many advantages that make Rodale devices outstanding time and money savers. Mounting screws placed and ready for action . . . green hexagonal grounding screws for wiring convenience . . . sturdy construction and quality controlled production . . . all yours when you specify Rodale.









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Sylvania's NTWWS-2V28-RLM.
One of Sylvania's complete line
of Very High Output fixtures.

This fixture, with its wider 16" reflector, received immediate RLM approval, after testing, when the new RLM specifications for 1500 MA fixtures were announced.

Sylvania's broad line of Very High Output fixtures, using the powerful 1500 MA lamps, provides a *practical* and *economical* solution to a vast range of lighting problems.

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And they cut down on initial costs, too, by saving 10¢

to 50¢ per square foot in the average installation.

Look into the advantages of using 1500 MA fixtures for your lighting. And be sure of getting quantity and quality by insisting on Sylvania's Very High Output fixtures.

Complete technical and photometric information will gladly be sent to you upon request.

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UNIQUE CUSTOMER ADVANTAGES

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Sorgel is historically known throughout the industry as the pioneering designers and manufacturers of quality dry-type transformers. Since 1916 this has been the principal product at Sorgel. Because of this long-time specialization and the experience of our engineering department, you are assured of immediate personal attention on any request or order. The combination of immediate service, product advantages, and competitive prices make Sorgel Electric the first choice of any consulting engineer, plant engineer, contractor or end users wanting a continuous, dependable transformer performance. The people who specify Sorgel are specifying the economies found only in our quiet quality products.



#### THE SORGEL SERVICE

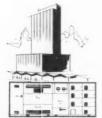
Prompt, efficient attention to your inquiries, orders and deliveries Sorgel's competent staff of experienced engineers, salesmen, sales representatives and factory personnel are trained to serve you immediately when you call. When your inquiry is received it gets immediate, personal attention. Each order is carefully reviewed as to specifications and delivery requirements. Prompt acknowledgment is made and almost immediately your transformer starts through our efficient production scheduling.

#### THE SORGEL PLANT

Where imaginative progress has been, and is being made

Continued modernization of our facilities and the growth and additions of talented engineering personnel have made possible the many new improvements and developments of our complete family line of sound-rated dry-type transformers. We take pride in keeping ahead of the present pace and engineering for the future. That's why Sorgel is known as the pioneer of sound-rated dry-type transformers for use in all sizes and all voltages.





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In the Transformer Field, Quality Is Economy

It's a proven fact that the initial cost of a second-class transformer is usually not the final expense. Breakdowns and extra maintenance costs mount fast. Not with our line! Sorgel sound-rated dry-type transformers are designed and carefully manufactured to provide you with ease of installation, the ultimate in efficiencies assuring lowest operating cost at all loads, overload capacity and long-range economy.















Complete Line for Every Purpose up to 10,000 Kva, up to 15,000 Volts, Including Special Transformers and Saturable Reactors

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## NEW PRODUCTS CATALOGS, BULLETINS ADVERTISEMENTS

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• PRODUCT NEWS, PRODUCT BRIEFS:

Use first line of boxes. Insert item numbers of products on which more information is desired.

 CATALOGS, BULLETINS AND ENGINEER-ING DATA:

Use second line of boxes. Insert item numbers of literature desired.

ADVERTISEMENTS:

Use third line of boxes. Insert page numbers of advertisements on which additional information is desired. Where more than one advertisement appears on the page, include the manufacturer's initials.

#### IMPORTANT...

- PLEASE PRINT LEGIBLY
- USE BLACK OR DARK BLUE INK
- O DO NOT USE PENCIL OR RUBBER STAMP

#### **Product News**



#### Lamp Annunciators (1

A new line of flexible, modular industrial lamp annunciators and annunciator systems has been introduced. Plug-in circuits which can be removed and changed for different operational sequences, multiple lamps to insure a signal even in event of lamp burn-out, quick change "snap-in" indicator plates, sequential circuits, data-logging terminals, snap-fit onepiece molded lamp compartments that can be removed without tools, are some of the features of new systems. In operation, lamp annunciators will detect and indicate. visually and audibly, any abnormal condition or change in status; then, based on information received, they can start up or shut down any desired machinery; feed information to data-logging or other control equipment; and finally, reset themselves, ready to perform again.

Industrial annunciators include all basic components of a complete system: lamp indications, "plugin" circuits, audible signals, plus provision for remote acknowledgment, lamp test, and reset pushbuttons. Three types of steel cabinets are available, flush panel mounted types with rear access terminals, flush wall mounted types with front access terminals, and surface mounted types with front access terminals. Indicator sizes vary from 1- by 3-in. to 1½- by 2-in. to 2- by 3-in.

Edwards Company, Inc., Norwalk, Conn.

#### Circuit Breaker (2)

With the new duplex Pushmatic circuit breaker, the number of circuits may be multiplied without increasing the size of panel. Ideal for modernization as well as new construction where additional 15- or 20-amp circuits may be required

in the future, the duplex Pushmatic will fit any Electri-Center. With the installation of duplex breakers, a regular 8-circuit Electri-Center panel will accommodate eight lighting or general purpose circuits plus the main breaker, double pole, and a range breaker, double pole. By the same method, a 14-circuit Electri-Center control panel will accommodate up to 24 circuits plus the 100-amp 2-pole main breaker. Duplex breakers are designed for both manual and automatic operation. Both regular and duplex breakers have two separate protective elements-a coil-type solenoid and a thermal bimetal.

BullDog Electric Products Div., I-T-E Circuit Breaker Co., 7610 Joseph Campau, Detroit, Mich.



#### Switchboard

The VFS modular distribution switchboard meets all operating requirements up through 5000 amps with quick-make, quick-break switch action. Using QMQB switches for applications up to 1200 amps and SP-1 service protectors for applications up through 5000 amps. VFS switchboards are designed especially for use in medium and large commercial, institutional and industrial buildings where service needs range from 600 through 5000 amps, 250 and 600 volts. Switchboards will handle not only heavy continuous currents but will also give fault protection on short circuits up to 200,000 amps. Switches can be added, replaced or interchanged. Safety features are arc quenchers; load-break devices on all switches; external front operated handles; steel-front construction and total steel enclosures. Supporting switch units and connectting them to the bus are specially designed phenolic insulators which are capable of handling short-circuit stresses up to 100,000 amps.

Federal Pacific Electric Co., 50 Paris St., Newark 1, N. J.

# PRECISION ENGINEERED FITTINGS

M. STEPHENS MFG, INC.

814 EAST 29TH STREET LOS ANGELES 11, CALIF.

ADams 1-9147

THE FOLLOWING IS A LIST OF SALESMEN REPRESENTING M. STEPHENS MFG., INC.:

(\* Means rep. carrying stock)

\*Brenner Electrical Sales 305 Velasco Houston, Texas

Mr. W. A. Smith Brenner Electrical Sales P. O. Box 13001 Dallas 20, Texas

(3)

Mr. W. D. Reese Brenner Electrical Sales 2608 Parkview Drive Austin 5, Texas

\*A. Lee Clifford & Co. 1801 W. 18th St. Indianapolis 7, Ind.

Forrest E. Durnal 1121 Edgewater Ave. Ft. Wayne, Ind.

Charles W. Pfeiffer c/o A. Lee Clifford & Co. 1905 Bardstown Rd. Louisville 5. Kv.

Bill Crichton

Associates
Riverview, Florida

Mr. C. R. Maddex 5601 Suwannee Ave. Tampa, Florida

Mr. C. R. Stegin 2321 Riverside Ave. Jacksonville, Fla.

Mr. J. R. Heidenreich 1628 N.E. 6th Ct. Ft. Lauderdale, Fla.

R. H. Dirkes Co. 327 S.W. Blvd. Kansas City 8, Mo. \*Electrical Sales Co. 2525 W. Armitage Ave.

Chicago 47, III.

"Gregory & Flynn
4501 Perkins Ave.
Cleveland, Ohio
Howard Gregory
7807 Greenbriar Lane
Cincinnati 43, Ohio
Howard Flynn
11201 Frankstown

Pittsburgh 35, Pa.

\*Hoffman Brothers
5201 Martin
Detroit 10, Mich.

Keeler, White, Inc.
 523 N.W. Everett St.
 Portland 9, Ore.
 Keeler, White, Inc.

1041 - 6th Ave., So. Seattle 4, Wash. \*D. A. Marsden 118 W. 29th St. Charlotte, N. C.

R. E. Myers & Son 317 N. 11th St. St. Louis 1, Mo. M. Morin Rivera 1300 N. Broad St. New Orleans, La.

Electrical Sales Rocky Mountain 16 Wazee Market Denver, Colorado

Rouzer Sales Co.
 823 Marshall St., N.E.
 Minneapolis, Minn.
 Leonard M. Slusser

318 Dooley Block Salt Lake City, Utah \*Stanley Sales Corp. 1122 Folsom St. San Francisco 3,

Calif.

#### NEW!

ARROW (AH) HART

BUS

#### CONTROL CENTERS

TYPE "MC"

#### these advantages will help you

MUCH GREATER SPACE SAVINGS... because the Arrow-Hart Motor Control Units in these Control Centers are half the size and weight of comparable controls. ARROW-HART offers a control center with up to 10 Size 1 control cells in a single vertical section 90" high.

FASTER, LOWER-COST INSTALLATION ... because all controls are delivered in a single pretested, ready-to-install "package." If specified, all interwiring, sequencing, interlocking etc. are preengineered.

GREATER DEPENDABILITY . . . because of the superior performance of the individual Arrow-Hart Control Units and simplified maintenance because all controls are centralized in a single convenient location, away from shop dust and dirt. Individual cells are plug-in type for quick removal, replacement or re-assembly.

COMPLETE FLEXIBILITY, VERSATILITY . . . practically any desired combination of units can easily be assembled . . . or modified.

#### MOST COMPLETE LINES AVAILABLE ANYWHERE...

COMBINATION STARTER UNITS: Non-Reversing, Reversing, 2-Speed, Part-Winding, and Reduced Voltage Starter Types in NEMA Sizes 1 through 6... in combination with Fused or Unfused Disconnect Switch or Circuit Breaker of Thermal Magnetic or Instantaneous Trip Type.

ENCLOSURES: NEMA 1 (General Purpose), NEMA 1-A (Semi-Dustight), NEMA 3 (Outdoor), NEMA 5 (Dustight), and NEMA 12 (Industrial Use) — in standard or back-to-back arrangements.

WIRING: NEMA A, B or C-Class I or II.



WIRING COMPARTMENT

#### WIRING COMPARTMENT

70"

COMPARTMENT

#### TYPE MC-5 20" WIDE

Up to 5 Size 1 Control Cells

preferred for most general purpose industrial applications. OTHER CONTROL UNITS: Include Lighting Panels, Transformers, Metering Equipment, and a Complete Line of Pilot Devices.

GET COMPLETE INFORMATION NOW!

Write today for fully descriptive literature. The Arrow-Hart & Hegeman Electric Company, Dept. ECM, 103 Hawthorn St., Hartford 6, Conn.

ARROW AH HART

Quality since 1890

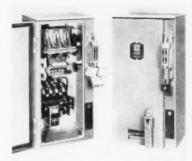
MOTOR CONTROLS . ENCLOSED SWITCHES

APPLIANCE SWITCHES . WIRING DEVICES

#### TYPE MC-10 25" WIDE

Up to 10 Size 1 Control Cells

preferred for schools and other commercial, and institutional applications that call for maximum space savings.



Starters

A new switch-type line of combination starters, furnished in NEMA 12 dust-tight enclosures, has been announced. Entirely new disconnect-switch and door-closing mechanisms have been incorporated in the new design to provide safety for both maintenance and operating personnel. Disconnect operating handle is permamently attached to switch. Handle is always in control of switch, regardless of whether door is open or closed, and door cannot be opened with switch on unless a by-pass is operated. Fuse clips are interchangeable, and can be spaced to accommodate either 250- or 600-volt fuses. Front operation of switch makes ganging easy, and through wiring simplifies installation. Bulletin SM-292 is avail-

Square D Company, 4041 North Richards St., Milwaukee 12, Wis.



Luminaire

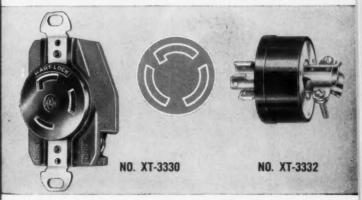
(5)

The new 6000 Series luminaire featuring crystal-clear, acrylic, prismatic controlens has been announced. It is 315 in. deep to ceiling line. Each of two lenses is made of one, single injection molded piece 4 ft long. Lenses are separated along center of fixture by a 3-in. wide ballast chamber cover recessed 1 in. above bottom of lens. Each Prismalume enclosure is held on one side by a steel channel riveted directly to plastic. On the other side, two 4 in. hinges provide relamping by a "free-swinging" attachment of lenses to fixture.

Holophane Company, Inc., 342 Madison Ave., New York 17, N. Y.

#### HART-LOCK HEAVY-**DUTY DEVICES**

INDUSTRIAL INSTALLATIONS



#### SINGLE 3-WIRE HART-LOCK RECEPTACLES, CAPS AND CONNECTORS—30 AMPERES, 250 VOLTS

Developed to insure safety in heavy-duty installations, this new line of Hart-Lock devices provides complete protection for industrial and commercial equipment that operates on 250 volts. The receptacle has black, glazed porcelain finish contact face, or is available with "NO-TRAK" face for heavy-duty industrial equipment. Serrations around terminal screws provide a secure grip for wires. Configuration prevents interchangeability with 20 amp Hart-Lock caps, connectors and receptacles. Caps and connectors have rubber ridge for better finger grip. Available in Arrow-Hart's exclusive armorover-rubber construction. Grounded Arrow-Hart's exclusive armor-over-rubber construction. Grounded units are also available.

#### "H&H" SPECIFICATION GRADES

**DUPLEX 3-WIRE GROUNDING RECEPT-**ACLES AND CAPS-15 AMPS, 277 VOLTS

Provides positive grounding for commercial fluorescent fixture installations equipment, plus locking to prevent accidental disconnect. Available both back wired and side wired, receptacle has 2 green hex grounding screws. Caps available in rub-ber or in armor-over-rubber.



NO. XT-4776



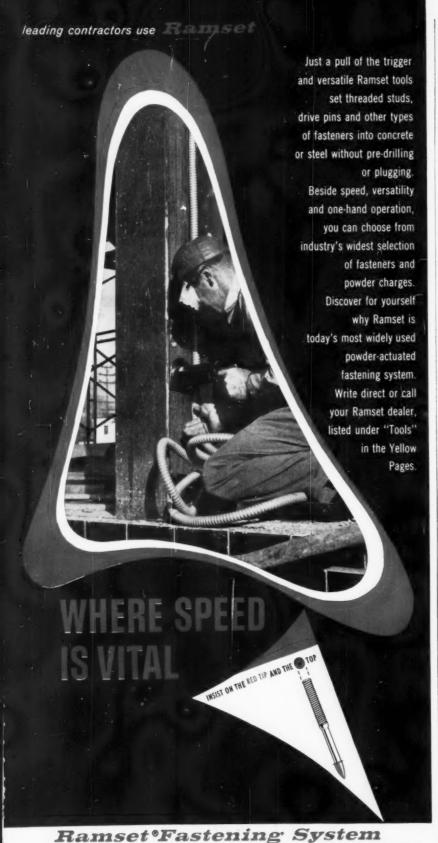
NO. XT-4750

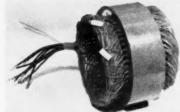
There are Arrow-Hart locking devices for every industrial, commercial and residential application. And each A-H device is designed for easy, fast installation and safe, reliable operation. Your customers will appreciate the added protection of Arrow-Hart products. Write today for information.

Dept. ECM, The Arrow-Hart & Hegeman Electric Co. 103 Hawthorn St., Hartford 6, Conn.



WIRING DEVICES . APPLIANCE SWITCHES





Motor

(6)

A new kind of motor overload protection, called Thermo-Tector, is available on all G-E Tri-Clad '55 3phase induction motors up to 125 hp, frame sizes 254U to 445U, in any insulation class or enclosure. Protection is provided by two or more miniature heat-sensing switches buried in stator windings. Switches, connected in series with conventional motor control, shut motor off whenever internal winding temperature exceeds a predetermined amount regardless of rate of temperature rise. Under rapid rise the switches "anticipate" and open circuit at a lower temperature than when rate of rise is slow.

General Electric Co., Schenectady 5, N. Y.

#### **Fittings**

(7)

Additions to this line of malleable iron electrical fittings have been made. An entrance cap for 3-4/0 and 3-2/0 service entrance cables, equipped with a non-water-tight connector and slotted mounting brackets; and two new hex-nut style malleable iron water-tight connectors. The two connectors are both 2-in. hub thread size with vinylite sealing bushings sized to accommodate different diameter cables. A new one-hole malleable iron-hot dip galvanized oval cable strap is designed for 3-4/0 S.E. cable and 3-2/0 bare cable.

Gedney Electric Company, Radio City, New York 20, N. Y.

#### Electric Plant (8

A new 50 kw electric plant available in various models for gasoline or gas-gasoline operation, for radiator cooling or city water cooling, and for any standard voltage desired. Unit has a revolving field, 12-lead reconnectible generator designed to crank electrically through the direct-connected exciter. An automatic voltage regulator is standard equipment. Gasoline engine powering it develops 104 hp at rated speed of 1800 rpm.

Kohler Co., Kohler, Wis.



STEADY AS SHE GOES! Twelve years ago, Phoenix Steel Corporation was having trouble with its magnet crane cables. Phoenix tried many commercial grades, but after a few months of constant flexing the individual conductor strands would break and puncture the insulation. With Okocom magnet crane cables, however, Phoenix has been getting excellent service that keeps the cranes operating continuously and efficiently.

#### Cable'bility at work

## Okocord stops strand breakage during flexing, assures power for Phoenix Steel magnet cranes

Cable'bility (cā'ble·bil'·i·ty) new word.
Noun. 1. Ability to design and manufacture electrical cables that give outstanding performance.
2. Having long background and wide experience in cable research and application. 3. Possessing keen understanding of customers' problems. Implies eagerness to serve faithfully and dedication to progress. Syn. The Okonite Company.

Magnet cranes give power and control cables a hard time by incessant reeling and unreeling as the magnet is raised and lowered. Many commercial grades of cable can't take it and fail after a few months' punishment. That's why Phoenix Steel Corporation of Pennsylvania has standardized on Okocord magnet crane cable.



Conductor, insulation, filler, sheath—all are designed for strength and flexibility. The short lay and assembly of conductors and fillers assure flexibility and compactness to withstand the constant bending and twisting of this tough reeling application.

Want to learn more about tough, long-lasting Okocord portable cables? Write for our 64-page Okocord catalog—EC-1108. The Okonite Company, Subsidiary of Kennecott Copper Corporation, Passaic, New Jersey.



where there's electrical power...there's OKONITE CABLE





#### ARRO EXPANSION BOLT COMPANY

DEPARTMENT D, P.O. BOX 388, MARION, OHIO



Ceiling Heater

(9)

A square-mesh grille is a feature of a new radiant heater, a surface mounted unit that extends  $3\frac{1}{2}$  in. from ceiling. Special grille pattern permits maximum heat radiation and diffusion with no drafts or cold spots. Quiet fan pulls air up through center of unit and disperses infra-red heat around outer edge. All exposed parts are anodized aluminum. Model 9290 has a specially designed armored-type heating element for instant heat.

NuTone, Inc., Cincinnati 27, Ohio

#### Meters (10)

A full line of standard VU meters conform to industry standards and are available with A or B scale plates. Meters are designed for broadcast monitoring panels, tape recorders, sound level indicators, PA systems, and wherever volume indicators are needed. They feature double bridge d'Arsonval movement with wide band, full bridge rectifiers. Available in  $2\frac{1}{2}$ -,  $3\frac{1}{2}$ -,  $4\frac{1}{2}$ -in. round or rectangular shapes.

Pace Electrical Instrument Co., Inc., 70-31 84th St., Glendale, L. I., N. Y.

#### Clock System (11)

A new clock system with a 12-hr corrective range synchronizes and corrects all secondary clocks and time clocks once each hour with an hourly corrective plus a 12-hr correction twice a day. In the system, all clocks can be set to correct time at any period of day from a central location. System can operate time recorders without an auxiliary relay device. It can also operate time stamps and program controls.

Cincinnati Time Recorder Co., 1733 Central Ave., Cincinnati 14, Ohio

SILVER KING SELF DRILLING SHIELD hardware or

See your industrial,

electrical supplier



and there are other benefits too... such as peak light output, long lamp and ballast life, positive starting, dependable service. Because CBM ballasts are made to definite specifications... checked and certified by ETL. And of course, they're UL listed. It pays to specify fixtures with CBM ballasts. For the latest dope, ask us to send you CBM News.

CERTIFIED BALLAST MANUFACTURERS, 2118 Keith Building, Cleveland 15, Ohio.

Participation in CBM is open to any manufacturer who wishes to qualify.



#### WILL YOUR "GROUNDS" CARRY IT?

During seasons of electrical storms, a careful program of checking all ground connections may save your company serious outages and property damage. Nine tenths of industrial lightning damage is reported to be on vital electrical equipment—motors, generators, transformers. Experience shows that ground resistance does not remain constant. Tests should be made at least once a year, and high ground resistance corrected.

#### Do You Have This Information File on Grounding?



The James G, Biddle Co, File 25 is an excellent fund of information on grounding problems. It includes a Manual on Ground Resistance Testing, and Bulletins on "Grounding Electric Circuits Effectively" and "Grounding Principles and Practices Applied to Industrial Plants."

USE THE MEGGER\* GROUND TESTER

To test ground connections, the easiest, quickest, and most dependable method is the use of the Megger Ground Tester with its own hand generator for current supply. Reading the resistance value is as easy as reading a voltmeter—directly in ohms. Only one set of connections, one operation, without any calculations. Each instrument is self-contained, rugged, and portable. Its cost is a small fraction of the savings resulting from adequate grounding protection.

Write for Ground Testing File 25-ECM.

81010



#### JAMES G. BIDDLE CO.

Electrical & Speed Measuring Instruments

1315 ARCH STREET . PHILADELPHIA 7, PA.



#### Electric Baseboard

(12)

A new 2-ft electric baseboard, known as Spartan B5, has a 500watt rating. It has a double thickness deflector, which lowers surface temperature by 20 degrees. Shipping weight is 9 lbs.

Spartan Electric Radiator Corp., 52-55 74th St., Maspeth, L. I., N. Y.

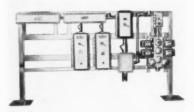


#### Fluorescent Fixture

(13)

Multi-application fluorescent fixture is for use in kitchens, pantries, over mirror in lavatory, in laundry or utility room, recreation or work room. It uses two rapid start fluorescent lamps (F40T12); clear plastic lens; chromium end plates; mounts flush to ceiling or wall; and measures 48½ in. long, 9 in. wide and 3 in, deep.

Virden Lighting, 5209 Euclid Ave., Cleveland 3, Ohio



#### Switch Racks

(14)

Custom-made switch racks complete with panelboards, circuit breakers, motor starters, and disconnect switches are now being produced. These new rectangular aluminum racks are particularly suited for compact mounting of switch rack components for either outdoor or indoor use.

Killark Electric Manufacturing Co., 3940 Easton Ave., St. Louis

13. Mo.

(15)

A new lightweight epoxy resin current transformer, Type TWM, is for indoor-outdoor light-duty metering. Designed in four current ratings-200:5, 400:5, 600:5, and 800:5 amps-it can be mounted vertically, horizontally or in an inverted position. Window openings of highest current rating can accommodate two 750 MCM or three 500 MCM insulated cables. Primary and secondary polarity marks are cast in transformer. Secondary terminals on top of transformer are protected by a weather-resistant sealable cover. Transformer is easily adapted for conduit type hook-up and can be used on 2- or 3wire, single and polyphase circuits. Allis - Chalmers Manufacturing Co., Milwaukee 1, Wis.

Motors (16)

Redesigned to meet new NEMA specifications, Type RS dripproof general purpose motors feature cast iron frames with integrally cast feet. Other features include solid die cast rotors with dual integrally cast cooling fans; entire rotor assembly is dynamically balanced. Mylar insulated throughout for high dielectric strength and compactness. Dripproof enclosure is furnished throughout entire frame size range. Rerated motors operate continuously at a rated temperature rise of 40° C. They are available for 3- or 2-phase, in all standard frequencies and commercial voltages below 600.

Lima Electric Motor Co., Inc., Lima, Ohio

#### Outlet Boxes (17)

Nine new types of 31 in. and 4-in. octagon outlet boxes have been added to this line. Boxes are standard drawn 12-in. deep types. Choice of BX clamps for installing armored cable and flexible metallic conduit, or Romex clamps for nonmetallic sheathed cable and flexible tubing. All clamps have nested fit. An extruded hole for clamp screw attachment doubles the number of threads available. Both styles can be supplied with mounting ears or with "J" type brackets welded on the side. Standard ½ in. knockouts, or combination 12-3 in. for rigid metallic conduit are available. Literature is available.

Keystone Manufacturing Co., Warren, Mich.



Positive Traction... Hydraulic Variable Speed Drive Convenient Control... Virtually Effortless Operation

Here's the finest, most advanced utility trencher available. The Davis T-66 has been designed and produced after an exhaustive survey determined the features users really wanted. Every one of its 1350 pounds is packed with performance to handle 9 out of 10 jobs with such efficiency and economy that you're bound to make more profit. And, it's priced far less than you would expect.

Positive traction, accurate speed control, and distribution of power where you need it is obtained through the use of tracks and a variable speed hydraulically for depth control, and it has a built-in pre-loaded shock absorber which cushions the shock but doesn't absorb the power. Everything is designed for the operator's comfort and convenience—requiring very little skill or effort. It digs 3" to 4" wide to 66" deep; or 12" wide, 30" deep and at varying widths and depths in between. Only **two tooth combinations** are required to let you dig at all widths. It trenches from 1-ft. to 12-ft. per minute depending upon soil conditions. It is compact, only 3" wide. The Davis T-66 is quality built in every part. It pays off in 33 ways!

ASK ABOUT ITS 90-DAY UNCONDITIONAL GUARANTEE

#### DOES ITS OWN BACKFILLING

The Davis T-66 has a low-cost, well designed, hydraulically controlled angle backfill blade. The T-66 has two-speed drive with instant forward and reverse, powered steering, independent left and right positive clutches and disc steering brakes for maneuverability in backfilling.



the DAVIS HUSTLER UTILITY TRAILER



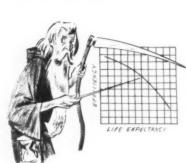


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#### YOU SPEND NEARLY \$2.50 TO OPERATE A 25 CENT LAMP

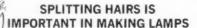
Feeds of Lie

The electric power required to operate a 25 cent incandescent lamp will amount to nearly \$2.50 before the lamp burns out. The efficiency with which a lamp converts electric power into usable light, then, is an important factor in considering lamp value.



## YOU CAN'T GET BOTH HIGH EFFICIENCY AND LONG LIFE IN INCANDESCENT LAMPS

General service incandescent lamps are designed so that the ratio between life and efficiency results in lowest overall lighting cost for the average installation. When efficiency is increased, lamp life is shortened. When lamp life is extended, efficiency goes down. Occasionally it makes sense to sacrifice efficiency for long life; for instance, when installing "long life" reflector lamps in inaccessible locations to minimize the high maintenance costs.



The filament wire in some incandescent lamps is only 1/5 the diameter of a human hair. A variation of only 1% in this tiny diameter can affect lamp life by 25%. Needless to say, it takes precision equipment and careful workmanship to insure that millions of bulbs a year pass Champion's rigid quality inspections.



In order to withstand abuse such as shock encountered in extension cord service, Rough Service lamps employ as many as 14 supports on the filament. Vibration Service Lamps also have special supports to withstand high frequency vibration such as produced by high speed machinery.

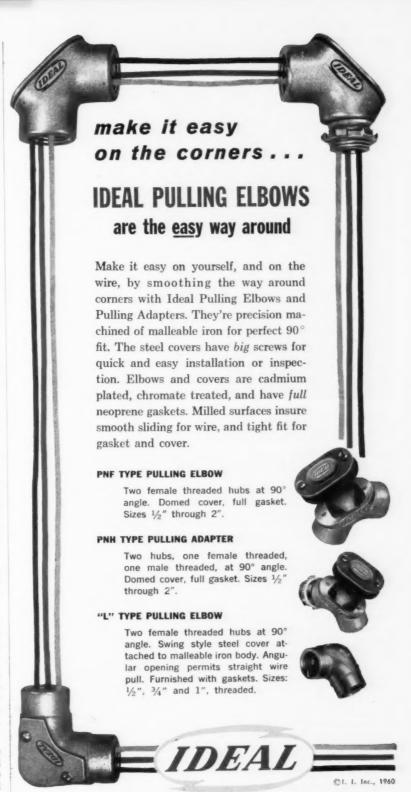
#### CHAMPION LAMP WORKS, Lynn, Massachusetts

CHAMPION INCANDESCENT-FLUORESCENT . YOUR BEST BUY IN LAMPS

## Catalogs & Bulletins

- (18) PORTABLE DISTRIBUTION. Bulletin TL-3, 8 pages, covers Porta-Watt systems for attachment to portable generator on truck or trailer, furnishing light and power for construction crews. Tuffline Div., Whitney Blake Co.
- (19) DISTRIBUTION TRANSFORMERS for floodlighting installations. Bulletin GEA-5683B, 2 pages, describes pole-type units. General Electric Co.
- (20) FLOODLIGHTS. 6-page catalog illustrates complete line of water-proof aluminum outdoor bullet-holders plus single, cluster, and pendant fixtures. Catalog LP-A. Stonco Electric Products Co.
- (21) NEMA STANDARDS publications currently available covering electrical manufacturing equipment are listed in new 1960 Guide, including brief descriptions of 20 new books produced last year. National Electrical Manufacturers Assn.
- (22) DISTRIBUTION EQUIPMENT. 84page "Buy Log" covers low-voltage equipment including service entrance equipment, safety switches, wireway, circuit breakers, switchboards, motor control centers, and busway. General Electric Co.
- (23) ALUMINUM FITTINGS. Condensed version of general catalog describes complete line of conduit bodies, connectors, couplings, boxes, receptacles, and others. Killark Electric Mfg. Co.
- (24) DISTRIBUTION EQUIPMENT. 300-page catalog describes heavy-duty electrical transmission and distribution equipment for commercial, industrial, residential, and government institutions, with specifications and prices. Continental Electrical Figuipment Co.
- (25) RELAY TESTING. Booklet contains information on line of testing units, with field experience data on classification of tests and test procedures. MULTI-AMP Div.
- (26) MAGNETIC STARTERS. Bulletin PL 12-8-160, 8 pages, gives engineering data on full range of sizes, 0 through 4. Clark Controller Co.
- (27) WIRE REELS which may be adjusted to fit truck beds, sides of truck bodies, and pipe rails are described in Bulletin 60010-CM3. Line Material Industries.

- (28) MOTORS, & through 10 hp. available with resilient mountings for quiet operation in hospitals, churches, and theatre air-conditioning applications are described. Wagner Electric Corp.
- (29) TEMPERATURE MEASURING Tempilstiks for checking temperatures of rotating parts and cooling objects are discussed in new data sheet. Tempil Corp.
- (30) SQUIRREL-CAGE MOTORS, 1 hp and larger. Bulletin MU-244 covers electrical and mechanical features of totally enclosed dripproof polyphase motors for close-coupled centrifugal pump applications. Wagner Electric Corp.
- (31) Ballasts for fluorescent lamps. 4-page Technical Letter 1-008 describes new solid-fill Dri-Lok ballasts which cannot leak. Jefferson Electric Co. Inc.
- (32) WALL FASTENERS. Information on attaching light- and medium-weight fixtures to walls with anchors using wood or sheet-metal screws is given in new bulletin. Star Expansion Industries.
- (33) Ballast technical engineering service, available on 24-hour basis without charge to aid in design, installation and trouble shooting. Universal Mfg. Corp.
- (34) CONDUIT BENDING. New 12page booklet gives tips on bending rigid steel and aluminum conduit and EMT, with step-by-step instructions on angle bends, stub lengths, back-to-back bends and offsets. Appleton Electric Co.
- (35) FISH TAPE. Bulletin describes Flexi-Strand round fish tape for use with aluminum conduit. Ideal Industries, Inc.
- (36) DRY-TYPE TRANSFORMERS for light, power and control, 4-page Bulletin S-202C describes complete line. Standard Transformer Co.
- (37) AUTOMATIC RECLOSERS. Bulletin GEA-7023, 8 pages, gives details of Type HR reclosers used for overcurrent protection on suburban and rural distribution systems. General Electric Co.
- (38) LIGHTING FIXTURES. Three new brochures describe exit and aisle lights, pendant and spin-up type contemporary luminaires, and round and square drum lights. Prescolite Mfg. Corp.
- (39) EPOXY RESINS—application to stators, armatures, field coils, transformers and other specific equipment. John C. Dolph Co.



SEE YOUR WHOLESALER, OR MAIL THIS COUPON. Attach to your letterhead.

IDEAL INDUSTRIES, INC. . 1841-E Park Ave., Sycamore, Illinois

Please send complete data on Ideal Pulling Elbows and Adapters.





# Just 1 Universal Die Head and 2 Sets of Dies Threads $\frac{1}{2}$ " to 2" Pipe and Conduit

Cuts Die Changing 66% —Two sets of dies do the work of six . . . adjust to size right in machine. One set for ½" and ¾"; the other for 1", 1¼", 1½" and 2". All other REDID quick-opening pipe and bolt die heads and dies can be used.

No Slow Back-Off — Quick flip of throw-out lever retracts dies instantly, after thread is cut.

Fast Chucking — RIPOID Speed Chuck grips tight, forward or reverse . . . sets and releases fast by hand. Tools swing out of way for chucking of short lengths from front. Always True Threads — Cam-action rear-centering device gives extra support for long pipe lengths . . . no wobble.

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Plenty of Power —Fast, trouble-free universal-type ½ h. p. motor, reversible at switch, easily threads up to 12" pipe with geared tools.

(40) SPOTLIGHTS which slide in track and may be moved at any time to fit lighting effects to changes in displays, etc., are covered in 6-page booklet A-477. Amplex Corn.

(41) PUMP MOTORS. 8-page Bulletin F-2000 contains details of submersible motors for 6-, 10- and 14-in. well diameters. U. S. Electrical Motors, Inc.

(42) PORTABLE CORDS and cables. New 52-page manual gives properties of 600-volt portable cables and mine power cables. Kaiser Aluminum & Chemical Sales, Inc.

(43) PROTECTIVE EQUIPMENT for linemen. 32-page catalog describes and illustrates rubber gloves and sleeves for use in working with high voltages. Charleston Rubber Co.

(44) Cable Spacers. Bulletin describes Wraparound spacers which support and space phase conductors in compact aerial cable system. PLM Products, Inc.

(45) INSULATING VARNISHES. Selection chart gives characteristics, recommended applications, and compatibility with various magnet wire coatings. John C. Dolph Co.

(46) CONTRACTORS AND STARTERS. Bulletin GEA-7020, 20 pages, contains information on magnetic controls in NEMA sizes 0 through 5. General Electric Co.

(47) Transformers. Brochure 139 covers entire line of both oil-cooled and dry-type lighting transformers. Niagara Transformer Corp.

(48) LIFTING MAGNETS for scrap handling. Bulletin 3021 describes lightweight, heavy-duty units. Stearns Magnetic Products.

(49) INFRARED OVENS and components for metal processing applications are covered in 8-page Bulletin 57-108. Fostoria Corp.

(50) MOTOR CONTROLS. Type RA magnetic starters and contactors, NEMA sizes 0 through 5, are described in new bulletin. Arrow-Hart & Hegeman Electric Co.

(51) RLM SPECIFICATIONS book, 1960 edition, features three new specifications and revisions to existing industrial lighting specifications. RLM Standards Institute Inc.

(52) SWITCH CUBICLES. Bulletin 18x9442 covers Type Q cubicles for housing manually operated disconnect switches for either load break or isolator duty. Allis-Chalmers Mfg. Co.

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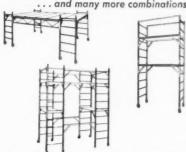
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### Reader's Quiz

QUESTIONS from readers on problems of industrial equipment, installation, maintenance and repairs. Answered by electrical maintenance engineers and industrial electrical contractors out of their experience. For every question and every answer published we pay \$5.00.

#### Heat from Lighting

QUESTION P37—In our local high school we have a heat problem which is due to incandescent lighting. One room where they seem to have the most trouble, there is 3300 watts. One engineer says if fluorescent lighting had been used the trouble could have been eliminated. Another engineer said that would not make much difference. Which engineer is correct? How many Btu's will 1000 watts of incandescent light give off?

Does 1000 waits of incandescent lighting heat as much as a 1000-watt electric heater? In other words, is part of incandescent lighting heat or other types of losses?—M.D.

ANSWER TO P37—Classrooms may become overheated even when the outside temperature is as low as 30°F in some cases, if the classroom has relatively large window areas and a south exposure. Let us assume the total heat gain to the classroom in question for two cases is as follows:

	SOUTH EXPOSURE	%	NORTH EXPOSURE	%
	Btu/Hr		Btu/Hr	
Heat from sun Heat from pupils	25,000	55.2 19.9	None 9,000	None 44.3
Heat from 3300 watts	11,280	24.9	11,280	55.7
Totals	45.280	100.0	20.280	100.0

So you see, if the overheated room is facing north the lights are contributing proportionately much more to the overheating of the room than if they were in a south facing room; but not as much as body heat or solar heat in either case.

Consider what would happen if fluorescent lamps were substituted for incandescent. Assuming the same fixture efficiency, 1200 watts of fluorescent lighting (including ballast losses) will produce approximately the same light as 3300 watts of incandescent lamps.

	SOUTH EXPOSURE	96	NORTH EXPOSURE	%
	Btu/Hr		Stu/Hr	
Heat from sun	25,000	65.6	None	None
Heat from pupils Heat from 1200		23.6	9,000	68.7
watts	4,100	10.8	4,100	31.3
Totals	38,100	100.0	13,100	100.0

To give a more tangible example, let us estimate the effect of the light on the room temperature under the following conditions: (1) heat from sun, 25,000 Btuh; (2) heat from pupils, 9000 Btuh; (3) outside temp., 60°F; (4) no ventilation air; (5) heating units off.

#### South Exposure

Incandescent lights on (3300 watts)109° F
Fluorescent lights on
(1200 watts)101° F
All lights off 97° F
North Exposure (no sun)
Incondescent lights on

In answer to your questions: (1) Which engineer is correct? I believe that both engineers are partly correct. The difference in the room temperature of 8° F between that using fluorescent and that using incandescent is not to be disregarded; however, as you can see for the conditions described, using fluorescent would not eliminate the overheating problem in the south exposed room. Mechanical ventilation of classrooms is required by law in some states and should be used in every case. Mechanical ventilation could be used to bring in outside air for cooling and would eliminate most overheating problems when the outside temperature is 60° F or below. Incandescent lights are usually the least expensive to install. Operation costs are higher; however, the heat from lights can be considered as part of the heating system to reduce its operating costs. With the facts as stated, I would recommend keeping your incandescent lighting system and provide mechanical ventilation, if necessary. If yearround mechanical cooling is necessary you should use fluorescent lamps.

(2) How many Btu's will 1000 watts of incandescent light give off? Answer: 3413 Btu per hour, a small portion of which may be transferred by radiant energy through the windows to outside the

(3) Does 1000 watts of incan-



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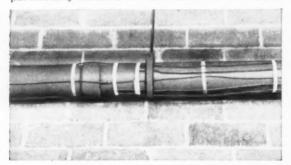
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The principal use for heating cable to date has been to prevent freezing of water pipe, oil lines, and other liquid or semi-liquid supply lines. It's particularly suitable for installations where even



the most efficient thermal insulation is insufficient to prevent a critical temperature change in the piped liquid.

G-E Wire and Cable distributors stock two types of pipe-heating cable, Deltabeston\* lead-jacketed asbestos heating cable, which dissipates heat at the rate of seven watts per foot, and silicone rubber heating cable that dissipates heat at 10 watts per foot.

Also available is Deltabeston lead-sheathed Flamenol jacketed heating cable specifically designed for melting snow. In light traffic areas (walks and outdoor stairways) this heating cable can be embedded directly in concrete or blacktop without any additional protection.

If there's a spot in your plant that needs G-E heating cable, and you want to find out more about what it costs and how it works, check off "Heating Cable" in the coupon, fill in your name and address, and mail it to G.E. We'll send you an interesting 10-page booklet that contains all the basic information.

# 2 Cutting the cost of outdoor lighting

Storage yards, truck docks, loading areas, plant exteriors — you can light them up brightly and safely without costly duct systems when you use

G-E Flamenol\* underground feeder cable (Type UF). This is the cable that's designed to give years of service buried direct, even in wet or corrosive soil. All the protection it needs is built-in: insulation *and* jacket are made of oil-, acid-, alkali and moisture-resistant Flamenol.

Since you can bury this cable direct, you get high-grade underground wiring at much lower installed cost.

Incidentally, the properties that make Type UF cable ideal for underground installation also recommend it for internal wiring, installed in the hollow spaces of interior or exterior masonry, or embedded in plaster.

G-E Type UF cable is available in single con-



ductor, and in two- or three-conductors with or without ground wires. All three types are available for immediate delivery from G-E distributors. To get more information about G-E Type UF Cable, fill in the coupon below, check the square marked "Type UF," and mail it to G.E.

# 3 Safe gas-station wiring without lead armor

It's no longer true that you need the strength of ten to wire a gas station, because General Electric has taken the lead out of gas station wiring. G-E Geotrol wire is much lighter than lead-sheathed cable, but it's as durable as leaded cable when it comes to resisting deterioration due to oil and gasoline vapors.

The job costs less with Geotrol, too, because it is priced considerably lower than lead-covered cable. And Geotrol makes the job go faster because it's so easy to work with. It has a smooth, hard finish that's a cinch to pull through conduit. It comes in five bright colors, so you can tell instantly which circuit is which. And it's easy to strip and simple to connect with standard fittings.

You can get all the Geotrol you need, promptly, from your G-E distributor. If you want a little leaflet with all the facts on Geotrol, for future

# many industrial problems...quickly



reference, fill in the coupon, check "Geotrol," and mail it to G.E.

# 4 Wiring to machine tools for maximum flexibility

Progress being what it is, chances are that a machine tool that's fine where it is now will be needed somewhere else in the plant a year from now. No cause for alarm, however, because with General Electric Flamenol bus-drop cable you can easily move machinery from one location to another without rewiring the whole system.

Installation flexibility is just one reason why G-E Flamenol bus-drop cable is a good choice. It has a remarkably long service life, too. The Flamenol jacket is made to resist all kinds of mechanical abuse. Flamenol takes no nonsense at all from oil, grease, acids, and alkaline cutting fluids.

Next time you're faced with the prospect of connecting low-voltage plug-in distribution buses with machine tool units, tell your G-E distributor. He has Flamenol bus-drop cable right in stock, and he can give you all you need without delay. If you simply want information for your file, G-E has a leaflet with complete information and specifications. You'll find this leaflet helpful for preliminary planning, and you can get a copy by filling in the coupon, checking "Flamenol Bus-drop Cable," and mailing it to G.E.

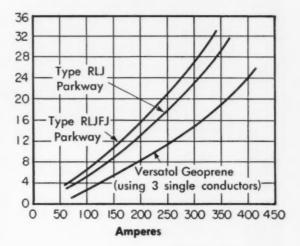
# **5** A versatile solution to many wiring requirements

Here's a competent and practically universal cable that's suitable for almost any 600-volt power or control circuit for 75° C operation: G-E Versatol\* Geoprene\* cable. Most types of Versatol Geoprene perform just as well whether they're in an exposed overhead location, run through conduit, or buried directly underground. Versatol Geoprene resists sunlight, moisture, oil, alkalies \*Registered Trade Mark of General Electric Company

and soil acids. It's flexible and easy to handle, but tough enough to resist abrasion damage.

Here's just a partial listing of some of the jobs Versatol Geoprene can handle: power distribution networks; lighting circuits; control circuits, such as leads from temperature-recording devices on rotating equipment to the switchboard; leads from current and potential transformers to the switchboard; motor leads,

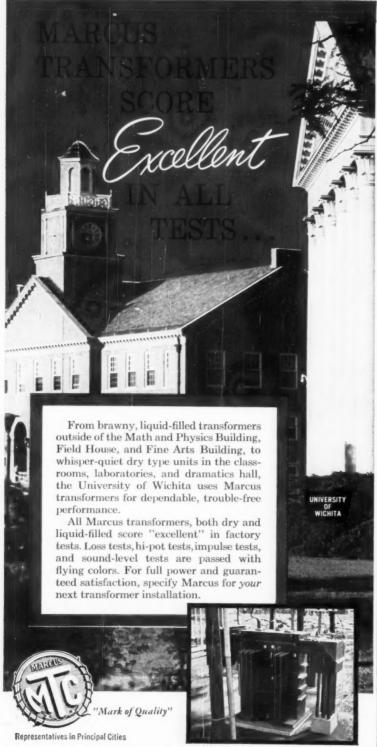
The chart below shows you the relative price advantage of Versatol Geoprene compared with other common types of cable for direct burial. Check it through, and if you find you need more information on Versatol Geoprene, mark it off on the coupon and mail it to G.E.



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descent lighting heat as much as a 1000-watt electric heater? For all practical purposes, it does.

(4) In other words, is part of incandescent lighting heat or other types of losses? For all practical purposes, the heat equivalent of all the electrical input to any lighting system contributes to the atmospheric heat of the space in which the lights and auxiliary equipment are located.

We have found that one of the causes of classrooms being overheated is uncontrolled or improperly controlled heating equipment.—S.G.F.

ANSWER TO P37—An electric light, be it incandescent or fluorescent, has only one function to perform, which is to convert as much of the electric energy supplied as possible into the visible energy of light. It is not a very efficient instrument, since a majority of the energy supplied is being wasted as far as production of light is concerned—it is converted directly into heat.

Some of this unwanted heat is dissipated by conduction and convection-heating of surrounding matter and air by direct contact. A good part of this heat is radiated directly into the surrounding space. The radiant heat is not of the same intensity as in the case of a heater, which, after all, is designed to transform the electric energy into radiated heat with only a small part of the energy appearing as light. The heater is more efficient as a radiant heat source and its effects are felt much sooner than from a lamp of the same watt-

As far as the heating of the room is concerned, 1000 watts lighting load will produce identical amount of heat as the 1000-watt heater, since ultimately the light, too, is transformed into heat by the lighted surfaces and the surrounding media. It may be mentioned here that light and radiant heat differ only in the wave length, both being a form of radiant energy. The band of visible energy or light extends from 4000 to 7000 Angstroms, while the radiant heat occupies the band above 7500 A in the electromagnetic spectrum.

Since 1000 watts is equal to 56.89 Btu/minute, the 3300-watt lighting load produces approximately 187.74 Btu/min. It does not make any difference whether this is incandescent or fluorescent load as long as the electric power input is the same for both.

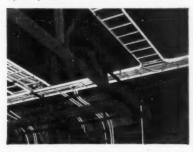
However, the incandescent light-

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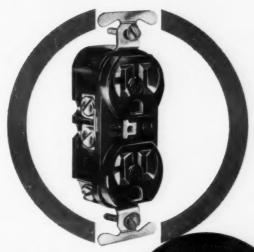
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ing requires more power to produce a given illumination level than the fluorescent lamps due to higher luminous efficiency of the fluorescent lamp.

This may be illustrated in the following way. The mean lumen output of 40-watt fluorescent lamp (preheat start, 48 in., SCW for example) is about 54 lumens/watt, while an incandescent lamp of same wattage produces only about 11 lumens/watt. Therefore 3300 watts of incandescent lighting load would produce 36,300 lumens. To obtain this amount of light from fluorescent 40-watt lamps only 17 units would be required. Assuming 11watt ballast loss for each lamp, the power requirement is only 867 watts, approximately, with resulting heat output of 49.32 Btu/min.

While the above computations appear to indicate the superiority of fluorescent over the incandescent lights in view of the resulting heat problem, other design requirements not mentioned may not have permitted the use of the fluorescent lamps for this installation.—A.A.B.

ANSWER TO P37-You haven't given enough detail, such as your climate, location of your hot classroom with respect to sun conditions, etc., to completely analyze your problem.

The engineer who suggested fluorescent lights was undoubtedly referring to the much higher lumens per watt ratios you obtain with fluorescent over incandescent lamps. Commercial fluorescent lamps yield about 70-75 lumens/ watt as against under 20 lumens/ watt for incandescents. What this means is that you could get exactly the same quantity of "seeing" light in your classrooms with only about 1000 watts of fluorescent lamps as you now obtain with 3300 watts of incandescent lamps.

If this were done, the new lighting system would save 2300 watts of heat in your classroom-also a very sizable savings in your power bill. To answer your last question, I think you would be safe in assuming that 1000 watts of incandescent lamps gives off into the area as much heat as a like size electric

heater.

Although I do think that the above will definitely help correct your problem, I think you should seek further other areas of abnormal heat gains for the classroom, such as uninsulated steam lines under the floor, too much sun exposure, roof reflecting materials, wall insulation, etc.-I.G.B.



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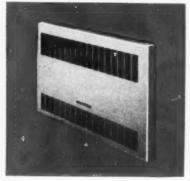
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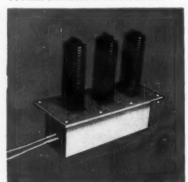
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would be good detection for bearings before they completely fail? We have experienced new bearings which failed within a short period causing a complete motor rewind.— E.S.H.

ANSWER TO R37—In reply to this question we naturally assume that the bearings in question were properly selected for the application.

From experience, I have found that about 98% of ball bearing failures are due to one of, or a combination of, the following causes:

No. 1 Improper lubrication—Certainly this is the major cause of all ball bearing failures. Improper lubrication includes insufficient as well as excessive amount of lubricant. Excessive amount of lubricant in ball bearings is one aspect of bearing failures that is overlooked but one that causes many bearing failures. The natural tendency when bearings overheat is to add lubricant, which only increases the overheating.

No. 2 Excessive bearing tension due to drive belt or chains.

No. 3 Foreign material entering bearings through seals or injected with lubricant.

Motor bearing failure can be detected well in advance of one point where the rotor will rub the stator and an inspection program to detect bearing failure is recommended. A simple, inexpensive listening device made by James P. Marsh Corp., Skokie, Ill., can be used to detect bearing failure. With its use and experience, faulty bearings can readily be detected.

If E.S.H. will set up an inspection-listening program, lubricate properly and adjust belt tensions properly, his bearing failures and motor burn out troubles will disappear.—J.H.P.

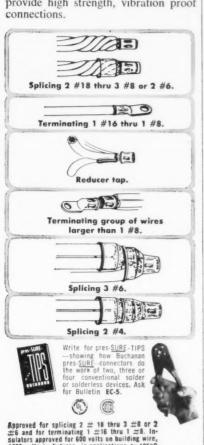
ANSWER TO R37—Ball bearings that do not perform as per design, and are progressing toward failure—generate heat that is in excess of normal operating conditions. This heat could be detected by miniature thermal detection devices. These thermal protectors automatically break the circuit when ball bearing temperature exceeds the preset limit. These control and detective devices are obtainable from Fenwall Inc., 113 Pleasant Street, Ashland, Mass.—A.S.J.

ANSWER TO R37—We have found that bearings pick up an awful lot of dirt before they are used. The questioner does not state whether the new bearings have been in-

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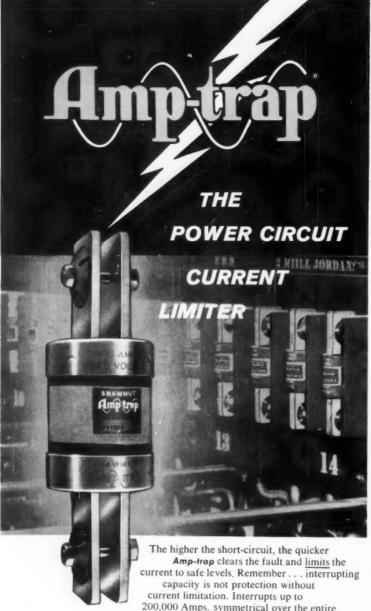
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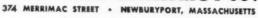


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#### **Bonding Conduits**

QUESTION Q37-In a group of six 21-in. conduits that come through a slab and are not joined to a junction box but are bonded by a ground wire, what rule is applied to size of bond wire?-V.S.

ANSWER TO Q37-In the NEC, it allows three 300,000 CM cables in a 21 in. size conduit; also in Table 250-94 (a), sizes of grounding conductors, it gives AWG No. 2 as the grounding conductor for service conductors up to 350,000. The No. 2 wire should be ample for your bond wire on the size 21 in. conduits .- E.S.H.

Editor's Note: The size of the bond wire will depend on whether the conduits contain service-entrance conductors or contain conductors that are properly protected by overcurrent devices.

If the conduits are service raceways, the provisions of Sections 250-71 and 250-72 of the NEC require a continuity of ground for all metal equipment and enclosures. One of the means of assuring such continuity is a bonding jumper.

Section 250-78 requires that a bonding jumper cannot be smaller in size than the corresponding grounding conductor, which for services, is covered in Table 250-94 (a) and (b). Assuming that each 2½-in. conduit contains three 300 MCM service conductors, Tables 250-94 (a) and (b) would require a grounding conductor of not less than No. 2. Then, as stated in Section 250-78, the same size bonding jumpers are required.

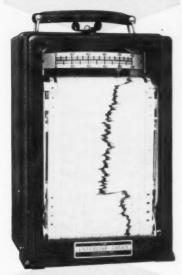
On the other hand if the 21-in. conduits contain 300 MCM conductors that are protected by overcurrent devices, the size of the grounding conductor and bonding jumpers are determined by Table 250-95. Normally, 300 MCM conductors would have overcurrent protection in excess of 200 amps. Therefore, the size of grounding conductor and bonding jumper would be No. 4 (per Table 250-95) where overcurrent devices protecting the 300 MCM conductors are from 201 to 400 amps,-J.H.W.

#### **Ball Bearing Failures**

QUESTION R37-Most of the ball bearing failures in electric motors cause the rotor to rub the stator which causes motor burnouts before the protective device will trip the current to the motor. What

## \ZZITA

- -AC Voltmeter? Yel
- -AC Ammeter ? Yes
- -DC Voltmeter? 44
- -DC Ammeter ? Yes



### Yes, the handy **Esterline-Angus** Multi-Purpose Recorder is all 4

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that have been failing. Assuming that it is new bearings put into old motors, I would say that these new bearings have picked up some dirt or grit. We have found that if the bearings are cleaned ultrasonically and then greased properly, the life of the bearing is extended a great deal. Ultrasonic cleaning removes the last bits of dirt, grime, etc., which are difficult or impossible to get out in any other way.

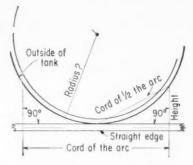
Once the bearing has been installed the motor can be checked

stalled into old motors or whether it is new motors with new bearings

Once the bearing has been installed the motor can be checked out using a crystal cartridge amplifier and loud speaker. Or, one can use an inexpensive record player by using the arm as a detector. Motions of the bearing will be transmitted to the needle and then, via the amplifier, to a loud speaker. A simple calibration can be made as to the amount of vibration in the motor, but actually, the different sounds that defective or poor bearings make will be recognizable.—H.H.S.

#### Conduit Bending

QUESTION S37—Shown is a diagram of a conduit bending principle or technique that appears to be a most practical approach to bending



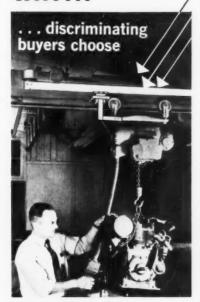
problems. However, we came into possession of the sketch minus a formula for defining its use. Can someone give me the needed formula?—W.A.

ANSWER TO S37—The following rule may be used to determine unknown radii pertaining to bends for tunnel ceilings, roofs, and the outside of tanks of large dimensions or duplicating existing bends.

Rule: Radius equals the chord of half the arc squared divided by twice the height of the arc.  $R = \frac{C^2}{24}$ 

For example: In your diagram if the chord of the arc measures 72 in. and the chord of half the arc meas-

### GOOD REASONS



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Rated at 120/240V AC, two- or three-wire service, this unit is available with indoor or raintight, tamperproof outdoor enclosures. Either way, it costs less than what you are used to paying for fused equipment with 200-ampere capacity after de-rating.

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3/4", 1" conduit

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for conduits
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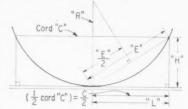
ures 40 in., and the height measures 16 in., we have 40 in.  $\times$  40 in. divided by  $2 \times 16$  in. or 1600 in. divided by 32 in., equals 50 in. radius.—P.A.B.

ANSWER TO S37—The accompanying diagram will suffice in explaining the formula W.A. requested. By measuring the length "L" and the height "H" which can be done by employing a square and ruler, these values are all that is needed.

Radius is then found equal to  $(L)^a$  plus  $(H)^a$  divided by 2H. I know that this works as I have employed it installing lights around tanks.

The length of the cord of one-half the arc is found by the solution of a right triangle; this is the hypotenuse of the triangle, whose base is ½ cord "C" and whose height is measured at right angle to the straight edge, and termed "H."

Solving for this radius
"R" equals E squared divided by 2H



Using the values of "L" or  $\frac{\text{"C"}}{2}$  and "H" we solve for "E":

$$E^{2} = \left(\frac{C}{2}\right)^{2} + H^{2}$$

$$E = \sqrt{\left(\frac{C}{2}\right)^{2} + H^{2}}$$

By the rule of similar triangles:

$$\frac{R}{E} = \frac{E}{\frac{2}{H}} \qquad R = \frac{E \times E}{2 \times H}$$

$$R \, = \, \frac{E^2}{2H} \, = \frac{\left(\frac{C}{2}\right)^2 \! + \! (H)^2}{2H} - \, F.N.S. \label{eq:R}$$

ANSWER TO S37—I purchased a book titled "Conduit Bending Manual" by Albert M. Kruger & Trafford J. Ferry, published June 1939 by C. B. M. Publications, 6555 77th Place, Middle Village 79, N. Y.

This small flexible bound book has the needed formulas as well as many other illustrations.

many other illustrations.

Rule: Radius equals the chord of half the arc squared divided by twice the height of the arc.  $R = \frac{C^2}{2A}$ 

### Can You Answer These QUESTIONS?

QUESTION A38-In our installation, consisting of a 480-volt, 3phase ring feeder that has a perimeter of 3000 ft, we recently installed a set of ground detector lamps, using three pilot lamp units, 6-watt, 120-volt, with resistors. These units were correctly wired to the main bus in the phase sequence A-B-C, When a test was made by temporarily grounding each phase, one at a time, through a resistor, there is a 180° reversal in the operation of the lamps. When the two main ring bus breakers are opened, the ground detector operates in normal phase sequence.

We have transposed the wiring so that the phase temporarily grounded shows a bright lamp and the other two are dim. As now connected, can we depend on this connector to correctly show a ground? What is causing it to operate in reverse?—W.F.W.

QUESTION B38—When drying out motors in an oven, occasionally you run across some which will reach maybe 5 megs when hot. Let the motor cool off, and the resistance will go to infinity. Theoretically, the resistance should be highest when hot—should it not?—S.J.P.

QUESTION C38—In the use of rigid aluminum conduit outdoors, are there rules for special fittings to prevent galvanized action? Must the conduit have air space for brick walls, concrete and wood walls? Must locknuts be cadmium plated? If used indoors, what fittings are required? Is aluminum conduit permissible in concrete slabs?—V.S.

QUESTION D38—About two years ago we installed a 4160-volt, 500-hp wound rotor motor. At periodic checks (every two months), we found the bolts on the resistor bank in the rotor circuit loose. We have been told that there is no solution to our problem, except that we should continue to check and then tighten as necessary.

Has any reader had similar experiences, and is there any way we can overcome the above condition?

—J.M.

PLEASE SEND IN
YOUR ANSWERS BY JUNE 15





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With General Electric's four types of underfloor wiring systems you can meet any electrical requirements in any type of floor construction. Here are the four G-E steel underfloor systems, and some of the features that make them so easy to work with:

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G-E Two-level System, for complex feeding problems, normally feeds through lower level, distributes through upper level. Requires  $3\frac{1}{2}$  inches floor fill. In multi-system installations, each system is completely separate.

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**G-E BIG DUCT** gives lots of capacity in a simple, low-cost system requiring only 3 inches of floor fill. Interior cross-sectional area is 8½ square inches. Increased cross-sectional area gives more work-space, makes wire pulling much easier.

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Enclosed is a description of my underfloor wiring problem. What do you suggest?	CityState

### In the News

#### EMEA of California Sponsors Electrical Show

The Electrical Maintenance Engineers Association of California this year included a comprehensive Lighting Conference as a feature of their concurrently staged 10th biennial Electrical Industry Show. which was held in Los Angeles during the period of March 23-26. The conference, covering a 5-fold field of industrial, school, office, store and outdoor illumination, was conducted as a series of parallel sessions. All subjects were repeated on different days to permit delegates to dovetail personal preferences with inspections of lighting, wiring and control equipment displayed by approximately 150 manufacturers.

Keynote speaker at the Kickoff Luncheon was Knox Bourne, vice president of McGraw-Hill's South Pacific District, who discussed Electricity's Share in the Golden Sixties. In so doing, he stated that "Just as problems of speed have suddenly been solved after countless centuries, so the advance of scientific knowledge is opening up all other fronts for us as well. The scientific world is moving forward with incredible swiftness, although the business world is not keeping pace, maintaining an attitude that is conservative, cautious and scared."

To take full advantage of coming opportunities, he continued, we must have both confidence and courage-confidence in a national economy that has progressed from a state of scarcity to one of surplus, and that has gradually developed a series of economic checks and balances which, conceivably, could "outlaw major depressions forever." Citing our booming population explosion and the related expansion of all types of goods and services, housing and electrical demands, Bourne concluded that we are riding the crest of scientific progress, and that we require only courage and confidence to capitalize on the bright promise of electrical growth in the coming Golden Six-

The actual conference program was introduced by George J. Taylor, immediate past-president of the IES and now vice president, Day-Brite Lighting, Inc., who defined new lighting "ground rules" by re-



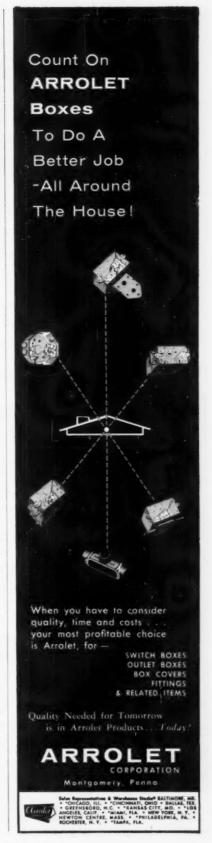
CHARLES M. TABOR of Larson-Hogue Electric Co., Los Angeles, and president of the Electric Maintenance Engineers Association of California, presided at that organization's biennial show-luncheon and discussed EMEA contributions to industry.

ferring to recent standards that have come into being as a result of the well-publicized Blackwell studies (see EC&M, June 1958) pertaining to requirements and recommendations for critical vision.

While pointing out that the Blackwell Report does not take into account such factors as color, contrast, glare and harmony, and that it does not consider such related items as posture chairs, air conditioning and eye-distractions that affect the efficiency of seeing, the report does present a reliable basis upon which we can now design lighting installations intelligently.

As speaker at another, subsequent session which considered Modern Trends in Office Lighting, Taylor maintained that good lighting is an additive quality combining light and sight with comfort, a combination that considers not only intensity, glare and proper shielding, but many related items of a psychological nature. The degree to which these various factors affect decisions, he stated, are governed considerably by personal understanding and objectives, since a businessman interested primarily in attracting attention to his store or tenants to his building could have a different objective than a personnel manager interested in morale, neater work, fewer headaches, accuracy and the like.

Emphasizing the importance of light and sight, he then referred to clinical findings that indicated that perception, appreciation and actions are dictated 87% of the time by sight, 7% by hearing, 3½% by smell, 1½% by touch and only 1% by taste. He also cited examples where elec-



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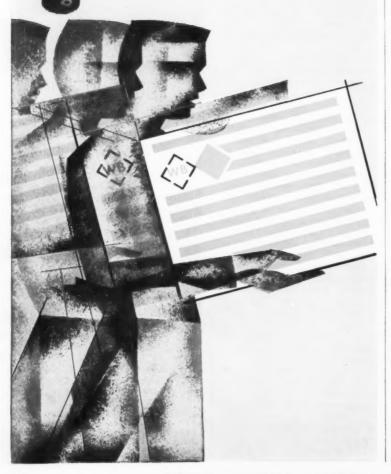
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trical benefits are now receiving far greater recognition in the building field. Lighting and wiring in a modern office building (in Atlanta, Ga.), for example, accounted for  $14\frac{1}{2}\%$  of the total building cost; air conditioning added another 14%, and elevators approximated 9% to bring the electrical combination up to  $37\frac{1}{2}\%$  of the whole.

High as these percentages are, however, he showed that, on a yearly square-foot-basis, "average" office lighting had a value of only 25 cents, as compared to wages of \$33, space at \$3.50, services at \$2 and office equipment representing \$1.25; and that, if by doubling the lighting investment, only a 5% boost in office efficiency would result, the overall net saving would amount to over \$1.50 per sq ft per year.

On the subject of Industrial Lighting in the Electronics Age, Robert Clubley, Lighting Consultant representing the G. E. Lamp Department, suggested that, with industrial processes becoming more complex while labor rates mount, lighting systems should be provided which will permit workers to see better and more accurately without excessive harshness, contrast, glare or disturbing shadows, thereby protecting a company's overall investment in the quality and quantity of their products. Good lighting, he said, is the first essential in the chain-reaction of seeing, recognizing, thinking and directing reflexes to accomplish tasks quickly and accurately.

One good approach to proper industrial illumination, he continued. is to design systems which will meet all requirements for general illumination, then to supplement these general patterns with higher-level local lighting which will provide direction, intensity and color additives to meet specific seeing tasks. As indicated by his further discussions, this could result in an industrial plant having a general lighting intensity in the 100-200-fc range, with local intensities rising to 1000 fc or more in concentrated areas where critical seeing is essential.

Another conference speaker was consulting engineer J. S. Hamel, who used an effective integrated-ceiling mock-up to emphasize his discussion of Lighting Combined with Air Conditioning. Maintaining that, with lighting intensities constantly becoming greater and resultant Btu emission progressing correspondingly, the cost of adequate air conditioning will soon become economically prohibitive un-

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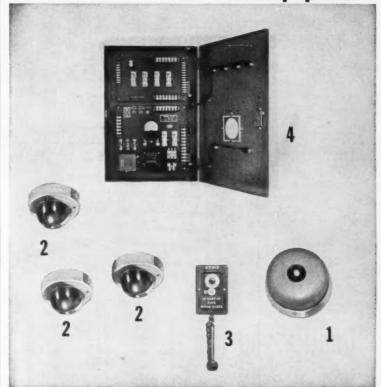
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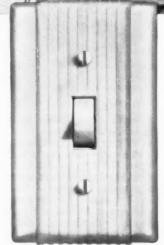
### Quality you can measure by Performance

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P&S Rocker-Glo can be used on fluorescent and tungsten filament loads at full current rating. Quiet in operation, it is smoothly activated by pressing, pushing, rocking or rolling.

Note: P&S Super AC Switches (20AC1) were also used in this building in all hallways and laboratories.

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WITH A STAGE SETTING depicting recommended school-lighting techniques, fenestration, color selection, brightness ratios, chalkboard and furniture arrangements, this important subject was discussed before EMEA conference delegates by John M. Chorlton, Toronto (Canada) Board of Education, and Charles D. Gibson, Director of School Planning for the State of California (2nd and 1st from right in the above picture). With them are Bill Jones of Smoot-Holman, who chairmanned these sessions, and committeeman Foster K. Samson, consulting engineer.

less these several separate services are combined into unified, efficient multi-purpose ceiling installations. In his interesting discussion, Mr. Hamel displayed a variety of recessed, semi-recessed and surface-mounted luminaires which were installed in combinations with linear air louvers with perforated grille strips, also with various arrangements whereby air supply and exhaust were incorporated into fixture designs reflecting new concepts of baffling, ballast location, and use of acoustical materials.

devoted to Various sessions proper school lighting were also well attended, these panels effectively combining theory with practice in the persons of John M. Chorlton from the Toronto, Canada, Board of Education, and Charles D. Gibson, Director of School Planning for the State of Calif. This presentation was staged in an unusually impressive setting, for the stage was designed to reflect recommended classroom procedures in the selection and mounting of fixtures, the selection of paints, chalkboards, brightness ratios and daylight fenestration.

Referring to laboratory findings by both Blackwell and Finch (see EC&M, Feb. 1959) pertaining to reflected glare and recommended placement of illumination sources, Chorlton presented considerable data to substantiate new recommendations relating specific reading tasks (pencil notes, carbon copies, printed matter) to specific lighting intensities.

The Art of Lighting for Merchan-

dising was another subject which was effectively presented by visual displays, actual lighting installations and slides. Using live models, fabrics, jewelry and glassware to illustrate their statements, the speakers discussed objectives, methods and results pertaining to light placement, direction, color and intensity.

As stated by Jerry Silvers, Globe Illumination, "Store lighting transcends the normal mechanics of providing X footcandles in Y patterns by utilizing Z luminaires. Rather, it must consider esthetics, psychological factors and overall motifs in order to glamorize both the customer and the merchandise, to excite or to lull, to create sparkle or diffusion. Light can influence traffic flow, create buying impulses, appeal to emotions, emphasize texture and similar physical properties."

This discussion was further illustrated by Ed Balogh of Sunbeam Lighting, who created numerous lighting effects to demonstrate recommended storelighting procedures, and who discussed many excellent colored slides showing merchandising settings of unusual merit.

The fifth conference topic, Outdoor Lighting, was subdivided into three categories: James M. Dowtin from General Electric discussing Street and Highway Illumination; A. L. Pryor, consulting lighting engineer, speaking on Parking Area Lighting; and William S. Shalda, representing the Shalda Manufacturing Co., analyzing Architectural and Building Flood-



LIGHTING PLAN for a 113-acre shopping center in lower California was explained to EMEA conference delegates by Consulting Engineer A. L. Pryor, who used a back-lighted multi-color shadow box to dramatically focus attention upon various areas and lighting standards installed at this major shopping site.



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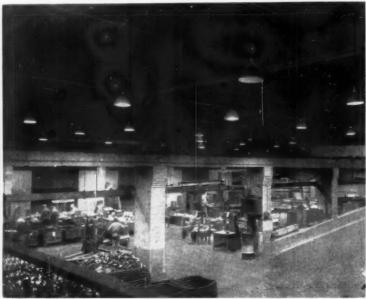
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MULTI RLM REFLECTORS AND FLUORESCENTS MANUFACTURED TO GIVE YOU EFFICIENT LIGHTING AND CUSTOMER SATISFACTION



PORCELAIN ENAMELED REFLECTORS



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Multi manufactures a complete line of quality lighting units, accessories, and fittings for Industrial Plants, Schools, Hospitals, and Airport Runway illumination. All components are processed and every unit is assembled, according to rigid standards of quality control, in our own plant. Precision workmanship, efficiency of design and high quality materials insure utmost satisfaction. See the Multi Catalog in Sweets or write for your copy today.



ELECTRIC MFG. INC. CHICAGO 24

SACRAMENTO 2-1900

lighting. Dowtin's approach included many case studies proving that higher lighting intensities resulted in marked decreases in accidents and death rates on highways and less crime on city streets. His discussions involved recommended procedures related to lighting not only streets and highways, but also to tunnels and bridges, interchanges and overpasses, entrances and exits from freeways, dangerous hills and curves, railroad crossings, direction sign locations, and both elevated and depressed roadways.

Pryor, in his talk on Parking Area Lighting, discussed step-bystep sequences followed in surveying, analyzing, designing, promoting, installing and testing results of a 113-acre shopping center (at La Marada, Calif.), one of the largest installations of this type in that state. In this review, he enumerated several mistakes repeatedly made in parking-area planning, such as faulty spacing, improper placement of luminaires, improper shielding, insufficient mounting heights, ornamental fixtures that do not deliver proper light patterns. He also showed how traffic can be directed to entrances or arterial lanes by using different colors, and he indicated how intensities can be built up progressively from 1 footcandle in some remote areas of the parking area to 100 fc or more in shopping-center show windows without compromising accepted standards for brightness ratios between adjacent areas of vision.



M. M. BRANDON, president, Underwriters' Laboratories, Inc., tells NEMA Electric House Heating Symposium in Chicago that the NEC is an "Installation Code"; that the UL follows the code in its investigations; that final decision on proper installation of electrical equipment and materials is up to local inspection

# LIGHTING Prices

You asked for it Now <u>it</u> is ready

A Brand New



#### NATIONAL PRICE SERVICE

### LIGHTING PRICE BOOK

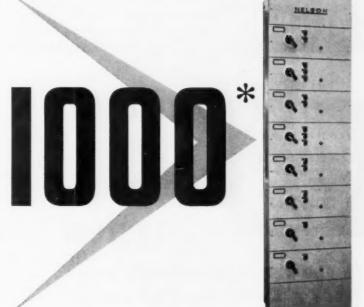
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\*1000 — that's the number of Motor Control Center structures Nelson has supplied to a single industry in just the last 5 years.\*\*

What better evidence of complete satisfaction could be desired? Nelson equipment is designed for complete dependability, easy installation, and is priced right.

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If quick shipment on Motor Control Centers is of importance to you, ask for a copy of Nelson's new QUICK-TROL Bulletin.

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Phillips RED HEADS are permanent concrete anchors with far greater strength and reliability than any other system. Everlasting holding power exceeds the strength of the bolt or the concrete itself. Cannot Pull Out \* Rust Out \* or Vibrate Loose.

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A COMPLETE LINE TO MEET ALL CONCRETE ANCHORING NEEDS







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#### SELF-DRILLING drills its own hole Case hardened steel teeth with hollow core cut

a smooth snug hole more rapidly than any other method. Hardened steel plug expands anchor for full dovetail grip. This is why the RED HEAD is rapidly replacing old-fashioned anchoring methods. This is why the RED HEAD is the MOST IMITATED concrete ancho



Impact Hammer or Hand Installation

SAFE, FAST, TROUBLE-FREE DRILLING AND **ANCHORING** 

A complete line of Interchangeable Chuck Assemblies and Hammer Adapters to fit all Makes and Models of Impact Hammers.

#### San Diego Contractors Win Award

A citation for "Outstanding Performance among Electrical Leagues in Promoting Residential Wiring" has just been presented to the Electrical Contractors Division of the Bureau of Home Appliances of San Diego County, Calif.

This citation, presented by Look Magazine for meritorious community service, engraved on a gold scroll mounted on a beautiful walnut plaque, recognizes the taste, effectiveness and educational value of the San Diego League's 1959 promotional efforts in the interest of residential electrification.

#### Matson Serves as CCECA President

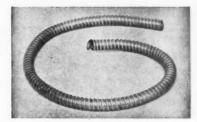
Louis Matson, Active Electric Co., Chicago, is the 1960 president of the Cook County Electrical Contractors Association headquartered in Chicago. Serving with him in the "official family" are: vice president-Carl Sievert, Sievert Electric Co.; secretary-A. L. Simmons, Clark Electric Co.; treasurer-Erwin Kaufmann, Kaufmann Electric

Members of the CCECA Board of Directors are: C. W. Arntzen, Arntzen Electric Co.; George Reinke, Reinke Electric Co.; Joseph Kunst, Jr., Principle Electric Co.; Tom Wigdahl, Wigdahl Electric Co.; Irwin S. Marks, D. D. Electric Co.; Howard M. Brown, Brown Electric Service; Bernard Braverman, Almart Electric Co.; Edward Reeve, Reeve Electric Co.; Henry Bell, Commodore Electric Co.; and Adam Sluis, Sluis Electric Company.



LOUIS MATSON (left), Active Electric Co., Chicago, accepts another term as president of the Cook County Electrical Contractors Association; grasps official gavel with retiring president William Veldhouse of Service Electric Company,

### INTERNATIONAL Electrical Conduit



### Finest Quality—Lowest Prices

International Metal Hose, one of the nation's largest producers of flexible metal conduit and tubing, utilizes modern equipment and automated processes to produce superior products at competitive prices. Ask International to quote your needs and compare price, quality, and delivery.

#### INTERNATIONAL SEALED SKIN

LIQUID-TIGHT FLEXIBLE STEEL CONDUIT (U. L. and J. I. C. Approved)

Strong, flexible metal core for simple, fast installation even in "U" bends and crowded quarters. Special polyvinyl corer is fiauid-tight, abrasion-resistant and provides permanent protection against oil, grease, weather, water, dirt, chemicals, fumes, and salt spray. Scaled Skin's Flexibility is especially adapted to provide connections between a moving member and stationary part and for resistance to vibration. It is easily cut to required lengths on the ference (1.1.6.) requirements, Packaged in a handy "playout" carton.

#### INTERNATIONAL U. L. & C. S. A. LABELED

FLEXIBLE STEEL CONDUIT

Made to Underwriters' and Canadian Standards Approval—meets all the rigid tests for flexible metal conduct conducted by Underwriters' Laboratories, Inc. Rust-resistant zinc coating gives longer protection against corrosion, dirt. Jumes, spray, and superior finish "dreases up" installaduit. Special built-in flexibility make installation casier—resists vibration—flexes into "U"bends—follows machine or installation contours. Especially adapted for connections between moving members and stationary parts. Comes in easy to-handle coils tagged with Underwriters' and C.S.A. Label.

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FLEXIBLE STEEL CONDUIT (Non-Approved)

Lower cost conduit for use where U.L. type is not necessary. Gives extra flexibility with economy, growides unexcelled, low-cost, crush-resistant shielding for floor, wall, ceiling cables. Electroplated to give rust-resistant ince coating. Superior finish "fresses up" installations. Automatic degreeating gives oil-free conduit. Easy to install—resists vibration—flexes into "U" bends and to follow machine or installation contours. Available in easy-to-handle coils.

#### INTERNATIONAL LIGHTWEIGHT

FLEXIBLE STEEL CONDUIT (Non-Approved)

A sturdy, lighter-weight flexible steel conduit at lower cost. Available in a wide range of sizes for most every need. Economical to use and to ship.

Send for specifications and price list

THE INTERNATIONAL METAL HOSE CO.



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### ... SPECIFY PARAGON

# 7000 SERIES puts automatic timing on easily controlled weekly schedule

For the 7-day time switch that is ideal for all heating, ventilating and air-conditioning applications, SPECIFY PARAGON'S 7000 SERIES. Handles four different voltages, and 40-ampere rating assures largest load-carrying capacity of any 7-day time control.

Turn any electrically controlled system ON-OFF automatically at different hours of each day. Days of the week are clearly separated . . . day and night periods divided, too, for easy-read, easy-set convenience. Any day or days can be omitted. Settings can be made a week in advance and changed as desired.

Get complete details on the 7000 SERIES now. Write for Bulletin 5976.



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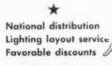
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### **RADIANT Merco-White High Beam features**

- \* Protected inner reflector; highest reflection factor.
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- \* Highest percentage of delivered lumens to work area.
- \* Higher initial and maintained illumination.
- \* Eliminates expensive, heavy fixtures. Reduces installation costs.
- \* Hard glass (Pyrex) withstands thermal shocks.
- ★ Combines two light patterns, narrow and wide, for complete coverage.









OUTDOOR

Send for Bulletin 89

DETROIT

Can use porcelain socket by itself in most locations Can use lightweight, inexpensive lamp



CHICAGO

### RADIANT LAMP CORPORATION

Industrial Lamp Specialists Since 1938

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Originators of Reflector Type Hard Glass R40, R60 & R80 Incandescent Lamps

#### NISA News

In a mail ballot last March, NISA members overwhelmingly supported the action of the NISA board of directors of last fall which authorized a change in the association name, effective April 1, 1961, to Electrical Apparatus Service Association, Inc.

The action restores the word "electrical" to the name of the association, whose members must be engaged in the service and repair of electrical apparatus to be eligible for membership. The organization was founded in 1933 as National Industrial Electrical Service Association, but the word "Electrical" was dropped soon after to encourage memberships from the mechanical service industries, firms that are no longer admitted to NISA.

E. F. Cochrane, of Alexander-Williams Co., Santa Ana, Calif., was elected president of Los Angeles Chapter at a meeting on April 12 at Palms restaurant, Anaheim, Calif. Other officers are: Orville Stump, Stump Electric Co., Los Angeles, vice-president; and Lloyd S. Cope, Advance Electric Co., Anaheim, secretary-treasurer.

"Father-and-son night" was celebrated by members of New York Metropolitan Chapter at Hotel Shelburne, March 17. NISA President Horace C. Blenkhorn and Executive Vice-President Joseph M. Harrington also attended.



QUAKER CITY Chapter, NISA, held its January meeting in Philadelphia during the Plant Maintenance Show in that city, and were hosts to the New York Metropolitan Chapter. In attendance at this meeting were (I to r): Joe H. Previty, Penn Electric Motor Co., Phila., Ralph O. Kufen, Kufen Electric Motors, Hatboro, Pa.; NISA President H. C. Blenkharn, Blenkhorn & Sawle, Ltd., St. Catharines, Ont., (Canada); Paul J. Duphily, president, Quaker City Chapter, Electrical Equipment & Maintenance Co., Milford, Del.; and Alfred Elson, Jr., New England Machine & Electric Co., Pawtucket, R. I.

# NEW KLEIN CATALOG



Here is the 1960 edition of the Klein catalog illustrating and describing the complete line of Klein tools and equipment for electricians.

It contains many new additions to the Klein line-including Replaceable Gaff Climbers, a newly developed Hot Line Grip and an even wider range of pliers for every purpose.

The Klein Catalog 103 will be of interest to linemen, electricians -good workmen everywhere.

Write for yours.

**Anchoring and Drilling Devices** for Fastening Anything to Masonry

### SABER-TOOTH Drill-N-Anchor

DURATHERM heat-treated self-drilling masonry anchor . . .

drills fast . . . only 45 seconds to install! Core-action cuts only the masonry around the hole's perimeter. Drills its own hole in even the toughest masonry, saves buying or sharpening drills, eliminates matching drill and anchor sizes, measuring for proper hole depth.



holds tight . . . over 9 tons for a 1/8" size! Teeth undercut the drilled hole and expand deep in the masonry, back-tapered ridges add holding power...the concrete or the bolt usually breaks before the anchor pulls out. UL, FM approved.

Hand Flush Type Tie Wire Type Rod Hanger Type Stud Type

RAWLPLUG

universal masonry anchors .now BRANDED "RAWL"

- · High holding power.
- · Smaller hole required . . . saves drilling time, cuts cost of drills.
- · Absorbs shock and vibration.
- · Eliminates need for hole spotting.
- · Economical to buy and use.

and a complete line of masonry anchors and drills including Calk-Ins . . . Spring-Wings . . . Lag-Shields . . . Rawldrills . . . Spiral carbide drills . . . and others... all in the new "Masonry Anchoring Handbook."



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The RAWLPLUG Company, Inc.

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Please send me a FREE copy of the "Masonry Anchoring Handbook with complete information about all Rawl products.



#### There's a Royal "POWR-KORD" for every need:

- . RUBBER or VINYL
- . BLACK or RED (rubber)
- RED or YELLOW (vinyl)
- . HANDY LENGTHS from 10' to 100'
- . IN THESE TYPES and SIZES: #18 and #16 SJ - 2- and 3-conductor #18 thru #12 S - 2-conductor #14 and #12 5 - 3-conductor #18 and #16 SJT - 2-conductor



### ... the all-quality line of all-purpose heavy-duty

Here's the kind of rugged construction that pays off on the job: MOLDED-ON caps and connectors, - built-in strain reliefs - Royalquality cord - heavy brass blades and double-wipe contacts - lockedin-place molded construction . . . and FULLY UL LISTED!

Next time you're ordering electrical supplies from your wholesaler, be sure to include Royal "POWR-KORDS".

#### ROYAL ELECTRIC CORPORATION Pawtucket, Rhode Island

In Canada: Royal Electric Company (Quebec) Ltd. Pointe-Claire, Quebec



ONE ATTRACTION of the Exhibit Booth of the National Association of Lighting Maintenance Contractors at the Plant Maintenance show in Philadelphia this year was a free-hand artist. Here he has made a caricature of Melvin H. Galbraith, (center), president of NALMCO, while E. 1. Creed, (left), NALMCO past-president, of C & S Lighting Maintenance, Cleveland, looks on joyfully. Artist is also a NALMCO member, Robert Brandenburg, of the Lighting Service Co., Milwaukee, Wis.

Other recent NISA meetings included a Heart of America Chapter gathering at Prom Motor Hotel, Kansas City, Mo., with Bruce Shaffer, Allis-Chalmers; Keith Blumhardt and Charles Johnson, General Electric Co.; and NISA Director Ben J. Horton, Atkinson Armature Works, Pittsburg, Kans., the principal speakers. . . . A New England Chapter meeting in Boston at Hotel Bradford on April 14, where a panel of shop men led a general discussion. . . . A meeting in Indianapolis of Indiana shop persons at which NISA President Horace C. Blenkhorn; Executive Vice-President Joseph M. Harrington; NISA Director Selden F. High, Sullivan Electric Co., Cincinnati, Ohio; and Dean Looman, Sterling Varnish Co., spoke. . . . The spring meeting of Rocky Mountain Chapter at Mayflower Hotel, Denver, Colo., where Ray Johnson, Tom Baker, Jack Bowe, E. C. Armstrong, James Chinn, Damon Ward and A. J. Morroni, members, and Walter O. Helwig, Helwig Carbon Products, Milwaukee; and John G. Cathy, I.C.S. representative, were speakers.

. . At a meeting on April 12 of the Chicago Chapter, D. L. Megchelson, manager, special report division, discussed credit and collections.

. . . Eldon Strom, of Strom Electric Co., Troy, Idaho, was elected president of Inland Empire Chapter, one of NISA's newest, at a meeting in Spokane on March 11. Others elected were F. E. Garrison, Tinling & Powell, Spokane, vice-president;

# Save Time, Money **Speed Installations** with ...

CABLE SUPPORTING SYSTEMS



P-W's TYPE "E" (PUNCHED BOTTOM) TRAYS—FOR POWER AND CONTROL CABLES AND INSTRUMENT TUBING-ALTHO LESS EXPENSIVE, ARE STRONG-ER, VERSATILE AND SUPERIOR. CONTROL CABLE CAN BE DROPPED OUT ANYWHERE,

Contractors and Installers look for QUALITY, LONG LIFE, AND LABOR SAVINGS in their supports. That's why more and more users are turning to P-W. Among our outstanding improvements are: CONNECTIONS that are quick and easy to install-PRE-CUT SYSTEMS savinstallation time-EXTENSION CON-NECTORS eliminating field cutting to complete runs — ADJUSTABLE HORIZON-TAL and RISER CONNECTORS to go over, under or around pipes, trusses, col-umns, etc. — BUILT-IN ADJUSTABLE DROP-OUT SECTIONS eliminate cutting out bottom of tray—STRAIGHT SEC-TIONS available in lengths up to 16' (331/3% less connectors and less installation

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P-W SUPPORTS are available in hot dip galvanized steel or aluminum, in LADDER, EXPANDED METAL and SOLID TRAYS in addition to Type "E". All systems are interchangeable. Write for Catalog 858-A.

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Exclusive "Kleanbore Priming

22 caliber Power Load (twice actual size)

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Scientifically graded Remington Power Loads offer precise, uniform charges . . . have strong, non-rusting brass cases. Exclusive "Kleanbore" priming mixture protects bore of tool because it does not cause rust or corrosion. No need to clean barrel after every job! These quality Power Loads are subjected to multiple inspection during manufacture, are backed by Remingtona name well known to American sportsmen. No matter what powder-actuated tool you use, it will work better with Remington Power Loads!

Uniform performance and penetration are assured with precision-made 14" and 34" diameter Remington Studs. These high-strength studs are made with special molybdenum steel. Specify Remington Studs with exclusive green "Power-Guide" heads . . . for uniform performance and straight-driving penetration. Over 60 "jobrated" Studs to choose from - your assurance of a Remington "Power-Guide" Stud to fit every fastening application.

Remington know-how insures the quality of its Studs and Power Loads. No other company can offer the back-

ground of experience gained through the manufacture of billions of these units. When you order studs and loads. vou'll get better performance if you specify Remington-maker of the most versatile fastening tool ever designed (right). We'll gladly send valuable free booklets about Remington Power Loads, Studs and fastening tools. Mail the coupon today!

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### BY SANGAMO TIME SWITCHES

Simple jobs, like lighting a vacationing family's house to discourage prowlers, or seeing to it that attic fans or air conditioning units operate automatically, are all in a day's work for Sangamo Types SJ and SR Time Switches.

When you have jobs like these, you do them simply and economically with these small, sturdy switches that can serve in virtually any single-pole, single-throw application. Customers are pleased because the switches are attractive and reliable. You don't make expensive call backs.

The Type SR Switch is designed for indoor installations, either surface mounted or on standard switch boxes with conventional wiring connections. The Type SJ Switch has a built-in receptacle, and is furnished with a 6-foot plug-in cord for portable use. Both switches are powered by a self-starting, high-torque synchronous motor (available in optional voltage ratings). Their heavy-duty silver contacts last for years.

See your favorite wholesaler who has a complete stock of dependable, maintenance-free, long-lived Sangamo Time Switches that can mean full-profit jobs for you.



**SPECIAL LICENSING** of electric heating contractors is subject of this post-session NEMA Symposium huddle between (L to R) C. R. Allen, Allen Electric Co., Anderson, Ind.; M. G. Bathe, Bathe Electric Co., St. Louis, Mo.; and G. C. White, Empire Electric Co., Ft. Worth, Texas. Reports, are that Anderson, Ind., now requires such a license.

G. O. Toms, G. O. Toms Electric Co., Spokane, secretary-treasurer; J. N. Mosch, Mosch Electric Co., Missoula, Mont., and H. T. Stoddard, Stoddard Electric Co., Orofina, Idaho, directors. Clifford Johnson, City Electric Co., Missoula, Mont., was admitted to membership at the meeting.

Otto Werner was elected president of Great Lakes Chapter at a meeting at Standard Electric Motor Works on April 18. J. R. Watterson was chosen vice-president; Harry Kerr, second vice-president; Joseph Bilicke, Stanley Graywall, directors. Charles E. Smith and William Howard, secretary and treasurer, respectively were reelected. Speakers at the meeting were NISA National President Horace C. Blenkhorn and NISA News editor Horace Barks. Hosts, in addition to Standard Electric Motor Works President C. S. (Pat) Moran, were Bill Cotter, Stan Polk, and Walter Beebe.

Connecticut Chapter met on April 7 at Waverly Inn, Cheshire, Conn.

Edwin B. Duckett, Electric Service & Equipment Co., Chattanooga, Tenn., was elected president of Mid-South Chapter at a meeting in Vicksburg, Miss., on March 11-12. Other officers were Norvell Ogden, Power Electric Co., Jackson, Miss., vice-president; William Howard, Standard Electric Machinery Corp., Montgomery, Ala., secretary-treasurer; and Gene L. Shiver, Tankersley Electric Co., Montgomery, Ala., director.

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NOW . . . drill

# ONE-INCH

every **30** seconds through

STEEL - REINFORCED CONCRETE

with the Mobile

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hydraulic-powered

DIAMOND CORING MACHINE

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ECONOMICAL



New Steber Series 5000-Rear Lamped Floodlights-are designed to meet NEMA Specifications FL6-210, Group B, Types I, II, III, IV and V. They accommodate G-48, 1500 watt, PS-52, 750-1000-1500 watt incandescent and 400-700 watt Mercury Vapor lamps.

In addition to "rear-lamping," Series 5000 floodlights include these exclusive Steber features:

- Genuine Silicone gasketing at all critical points
- Finned, cast aluminum neck and cap for maximum heat dissipation
- Shielded condensate drain
- Removable thermal shock and impact-resistant lens
- Rear section clips to trunion bracket, leaving both hands free for faster, safer servicing
- Positive grounding—both during operation and servicing

#### DELIVERIES

The well-known Steber "shipment within 16 working hours" policy applies to Series 5000 Floodlights, as well as to all other Steber lighting equipment. No need to wait 6 to 8 weeks or longer for "rush" jobs-specify Steber ond your delivery problem is solved.

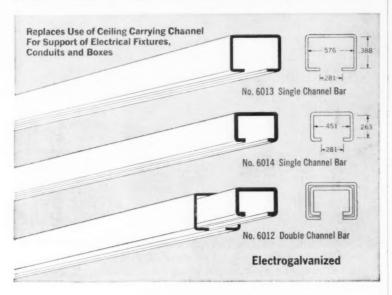
Write for NEW BULLETIN 1097 today!

Lighting Units STOBBER for Every Need

STEBER MANUFACTURING CO., DEPT. 98-E, BROADVIEW, ILL. Steber Manufacturing Co. of California, 242 S. Anderson St., Los Angeles 33, Cal. Divisions of The Pyle-National Company

# NEW! STEEL CI CHANNEL BAR

Mounts Fixtures, Boxes and Conduits in Suspended Ceilings



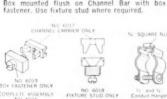
#### Steel City All-Purpose Channel Bars

Practical and economical for electrical installations in suspended ceiling construction. Slotted opening permits easy positioning of 6H-BB Conduit Clamps, standard 1/4" Square Nut and Threaded Rod or No. 6017 Channel Carrier using either No. 6019 Box Fastener or No. 6018 Fixture Stud to secure box. Designed in two sizes for maximum utility-used separately or as double channel. Packaged ten-10' lengths.

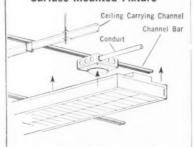
#### Simplified Hanging with Standard Electrical Fittings



Box mounted flush on Channel Bar with box fastener, Use fixture stud where required.



Typical Installation of Surface Mounted Fixture



Box on Channel Bar feeds and supports

Available now through leading electrical distributors



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STEEL CITY ELECTRIC COMPANY

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CONSULTING ENGINEER J. S. Hamel attracted SRO audiences to two successive sessions when he analyzed Integrated Lighting and Air Conditioning at EMEA's Lighting Conference which was held concurrently with the association's biennial electrical show in Los Angeles this past March.

George T. Kinard was installed as president of the Southwestern Chapter at a meeting in Dallas, Texas, March 10-12. More than 175 attended, from 15 states. Mr. Kinard is with Electrical Machinery & Repair, Beaumont, Texas. Other officers are: James A. Phares. Southwest Electric Co., Oklahoma City, Oklahoma, first vice-president; James M. Morgan, Central Electric Co., Fort Worth, Texas, second vice-president; and Connie H. Henry, Motor Rewinding Co., Dallas, Texas, secretary-treasurer.

Directors of the chapter include J. E. Hurt, Dallas; John F. Loyd, San Antonio; A. L. Miller, Houston; E. Arnold Tench, Shreveport, La.; and Ellis McMillin, Abilene, Texas.

#### III. Inspectors Want **Grounded Phase Leg** Marked

How should the grounded phase conductor of a corner-grounded 3-phase delta system be identified? Use of the code-recommended slate gray or white colored wire as the grounded conductor in such cases could be confusing and somewhat hazardous when other systems having grounded neutrals are in the same building. This problem came up for extended floor discussion at the winter meeting of the Illinois Chapter, International Association of Electrical Inspectors in Chicago.

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Now you can service, maintain, and calibrate industrial process instruments and controls easier and faster with the up-todate guidance you'll find in this handbook.

Here are thousands of step-by-step working in-structions for servicing equipment manufactured

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#### INDUSTRIAL INSTRUMENT SERVICING HANDBOOK

By GRADY C. CARROLL

Chief Instrument Engineer, Energy Division, Olin Mathieson Chemical Corp., Niagara Falls

848 pp. 6 x 9, 375 illus. and tables, \$16.00 EASY TERMS: Pay \$6.00 in 10 days; \$5.00 monthly

Industrial engineers and technicians will find in these expert pages a wealth of engineering data and methods for servicing modern industrial process measuring and control instruments.

This practical handbook will serve you as a concise review of the design and operational principles of many different types of industrial instruments . . . a ready guide to the most effective methods of service, maintenance, and calibration . . and a handy compliation of tables, graphs, photographs, schematic diagrams, and other useful working aids you'll constantly refer to.

#### Check these 13 big sections . . .

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  Velocity and Volumetric Measuring Instruments
  Liquid-level-measuring Instruments
  Temperature-measuring Instruments
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  Temperature-measuring Instruments
  Priscosity and Specific-gravity Instruments
  pH and Redox

  Measuring Instruments
  Control Valves and Valve Positioners
  Valve Positioners
  Cale Measure-ment and Control Repairing and Calibrating
  Controllers
  12. Organization of Instrument Department for Processing Plants
  13. Thermocouple
  Temperature-millivolt Equivalents

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1 Epoxy-cured finishes stay factory-fresh through severest weather. Resist salt-spray, corrosives.

Degree-marked pre-aiming quadrant.

Deep-gripping serrated teeth for focus lock-in.

4 Full-circle vented ribs (pat. pend.) - pull a moving, cooling air-stream up through the fixture and out.

5 Big internal heat-dissipating fins.

6 STONCO "Cushion-Seal" -- high-temperature live silicone-rubber weatherseal. Protects in any fixture position, even face-up.

7 Plenty of grip-space between lamp and

B Lifetime cast aluminum - with that solid heft indoor units just don't have.

A COMPLETE LINE FOR 75W-300W REFLEC-TOR LAMPS Single or cluster fixtures in 3 distinctive styles, wide range of finishes. For ceilings, walls, under eaves . . . all exteriors requiring a high-degree of architectural and color fidelity.

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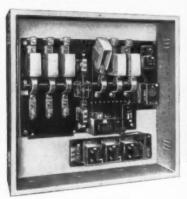
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STONCO ELECTRIC PRODUCTS CO. . KENILWORTH, NEW JERSEY

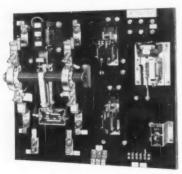
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engineered to assure continuous power, safeguard life, property, production.



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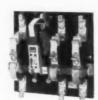
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NEW CHAIRMAN of the Illinois Chapter, IAEI, Lyle E. Dunham (left), Springfield, accepts gavel from immediate past-chairman Don E. Coutts, Chicago, at winter meeting of inspector group in Chicago.

The City of Chicago requires a 1-in. band of red tape be applied to the grounded phase conductor of a corner-grounded 3-phase system, wherever such conductor is exposed in an accessible box or terminal cabinet. Other inspectors agreed that grounded-phase conductor identification should be different from that of grounded neutral conductors but want such identification to be a universal type standardized by the code. To initiate action in this respect, Illinois inspectors approved a motion by Chicago's chief electrical inspector W. P. Hogan, Jr., that the Chapter Codes Standards Committee Chairman E. J. Boyle apprise the proper NFPA electrical code panel of this problem and enlist their consideration in an ultimate

A variety of subjects occupied the remainder of the two-day conference. J. V. McBride, chief engineer, The Plastic Wire & Cable Co., Jewett City, Conn., discussed recent developments in cable and cord insulations; E. C. Soares, Industrial Engineering Services, N. J., reviewed the basic elements of system grounding techniques; J. A. Pape, Commonwealth Edison Co., Chicago, reported a healthy increase in the number of electrically heated homes and apartment structures in Illinois. S. B. Cappell, Chicago electrical inspector, discussed the relationship of good workmanship to electrical fire safety, particularly with metallic armored cable systems. C. M. Clark, commonwealth Edison Company, Chicago, presented a highly interesting and informative movie and discussion of the Dresden Nuclear Power Station in Illinois.

At the concluding business session the following officers were

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Two, three or a small galaxy of outdoor lights come magically alight at dark, turn off at dawn. Built-in time delay avoids on-off flicker from car headlights. Satin aluminum standard exterior face plate, weatherproof gasket. 300W Capacity.



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And over mountains and down valleys, too. That's the communication system which was required for the Winter Olympics at Squaw Valley.

A complete sound and public address system—consisting of 16 separate sound systems—was installed over the sprawling, 6000-acre Olympic area. A series of switches gave the system the versatility it had to have; any number of individual sound systems from one to all 16 could be tied together for public announcements.

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# ...the most practical method of luminaire maintenance!

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elected: chairman—Lyle Dunhan, Springfield; first vice chairman— Wm. P. Hogan, Jr., Chicago; second vice chairman—Leland J. Hall, Orland Park; third vice chairman— Edward J. Boyle, Chicago. Clarence A. Wingfield, Chicago, is the Chapter secretary-treasurer.

Randall Beasley was elected chairman of the new Executive Committee composed of the following industry representatives: George Albiez (wholesalers); William Veldhouse (contractors); Le-Roy Block (manufacturers); Don Coutts (past-chairman) and Harold Hady (suburban inspectors).

#### **New Books**

Electric Heating and Cooling Fact Book, 52 pages, \$1.00. Electrical Information Publishers Inc., 2132 Fordem Ave., Madison 1, Wis.

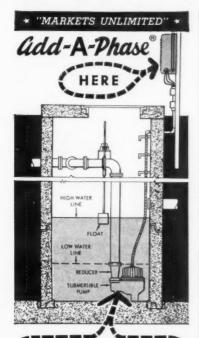
1960 issue contains over 240 listings of electric resistance heaters, heat pumps, and control equipment, with market information, hints on wiring, and a section on insulation.

ASTM Standards on Electrical Insulating Liquids and Gases, D-27, 336 pages, \$4.25. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa,

Typical of 48 standards included in this book are "Tests for Corrosive Sulfur in Electrical Insulating Oils" and "Test for Scavenger Content in Askarels." Valuable for those concerned with problems in high-voltage transmission.

Electrical Systems Design, by Joseph F. McPartland and editors of Electrical Construction and Maintenance, 220 pages, Second Edition, \$7.75. McGraw-Hill Book Co., 327 W. 41st St., New York 36, N. Y.

Modern standards, procedures, and developments in electrical systems design are brought together in revision of practical guidebook. Covering power, light, heat, air conditioning, signals and communications for industrial, commercial, and residential structures, the book relates services, feeders and branch circuits to modern design and basic safety requirements of the National Electrical Code. Over 200 diagrams and drawings show step-by-step procedures for selecting designs, for implementing these designs with actual equipment, and for incorporating the resulting system within the physical dimensions of the building.



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Now, get all the benefits of dependable 3-phase submersible pump operation and be assured of trouble-free, continuous full power output with the ADD-A-PHASE Power Converter. Absolutely no expensive 3-phase wiring necessary. The Add-A-Phase is easily installed by any qualified electrician.

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The installation of electric heating is no great mystery. Contractors, who once got scared off by strange phrases such as "heat loss," will wonder why they ever stayed out of this booming, big profit market. Electric heat is simple and Berko's new manual takes you every step of the way to complete and thorough understanding.

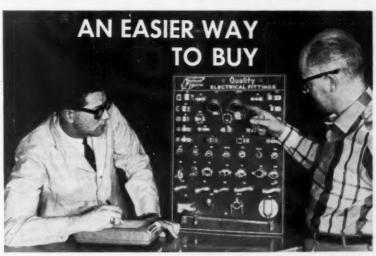
Using the manual, even the most inexperienced can quickly and accurately calculate heat loss, determine the number and type of units needed to adequately heat a room, approximate annual operating cost, gauge the effect of insulation, etc. The manual also contains the most complete, up-to-date geographical data charts available.

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#### DATES AHEAD

- Illuminating Engineering Society—Regional Conferences: Great Lakes, Carter Hotel. Cleveland, Ohio, May 16-17; Northeastern, Wentworth-By-The-Sea, Portsmouth, N. H., June 8-9; Canadian, Nova Scotian Hotel, Halifax, N. S., June 13-14.
- National Fire Protection Assn.—Annual meeting, Montreal, Canada, May 16-20.
- Pacific Coast Electrical Assn.—Annual convention, Stardust Hotel, Las Vegas, Nev., May 16-18.
- Design Engineering Conference and Show—Statler-Hilton and Coliseum, New York, N. Y., May 23-26.
- Construction Caribbean—A building materials show, San Juan, Puerto Rico, June 3-9.
- Edison Electric Institute—Annual Convention, Atlantic City, N. J., June 6-8.
- New York State Association of Electrical Contractors & Dealers—61st annual convention, Whiteface Inn. Lake Placid, N. Y., July 3-8.
- National Association of Lighting Maintenance Contractors—National conference, Milwaukee Inn, Milwaukee, Wis., August 22-24.
- Illuminating Engineering Society—National Technical Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., September 11-16.
- International Association of Electrical Inspectors Northwest Section, Sheraton-Portland Hotel, Portland, Ore., September 12-14; Southwest Section, Mapes Hotel, Reno, Nev., September 19-22; Eastern Section, Wentworth-By-The-Sea, Portsmouth, N. H., September 26-29; Western Section, Continental Hotel, Kansas City, Mo., October 3-5; Canadian Section, Toronto, Ont., Canada, October 8-9; Southern Section, Rice Hotel, Houston, Texas, October 17-19.
- Pennsylvania Electric Assn.—53rd annual meeting, Penn-Sheraton, Pittsburgh, Pa., September 20-22.
- NISA Chapter Meetings—Southwestern, Austin, Texas, September 22-24.
- International Association of Electrical Leagues—25th annual conference, Hotel President, Kansas City, Mo., October 5-7.
- National Electronics Conference—Hotel Sherman, Chicago, Ill., October 10-12.
- Florida Association of Electrical Contractors—Annual Convention and 8th Electrical Trade Show, Deauville Hotel, Miami Beach, Fla., October 12-15
- National Electrical Contractors Association—1960 annual convention, Las Vegas Convention Center, Las Vegas, Nev., October 23-27.
- National Electrical Manufacturers Assn.—Annual meeting, Traymore Hotel, Atlantic City, N. J., November 14-18.
- Electrical & Home Appliance Show— Electrical Building, Balboa Park, San Diego, Calif., November 25-30.

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PLUGMOLD 3000, for standard single-gang box devices. Holds, without devices, up to 10 No. 6 conductors.

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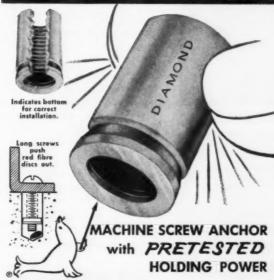
TELEPOWER is pair of parallel Plugmold raceways, one for communications, one for power and light.

ONE-PIECE raceway by Wiremold comes in four sizes for surface wiring of any

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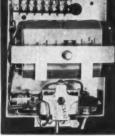


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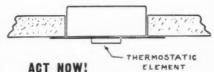
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#### Among the Manufacturers

**Headquarters Announcements** 

G. H. Leland Inc., Dayton, Ohio, has changed its name to Ledex, Inc.

Van Huffel Products, Inc., Warren, Ohio, has purchased the product lines of Power-Strut, Inc. and Decor Products, Inc. of Framingham, Mass., whose products will be manufactured by the Power-Strut Division of Van Huffel.

Edwin L. Wiegand Co., Pittsburgh, Pa., has acquired Barber Infrared Associates of Bradner, Ohio, as a subsidiary which becomes Radcor, Inc., with I. J. Barber as vice-president and general manager.

Rockbestos Wire & Cable Co., New Haven, Conn.—Eugene S. Reed, sales manager.

Van Norman Industries, Inc., New Bedford, Mass.—Charles B. Eisenhauer, general manager, Electronics Div.

I-T-E Circuit Breaker Co., Philadelphia, Pa.—William P. Bolger, manager of special products division; W. H. Edmunds, manager, small circuit breaker division.

Sorensen & Co., South Norwalk, Conn.—Julie Polis, assistant sales manager.

Raytheon Co., Waltham, Mass.— William H. Weed, advertising and sales promotion manager, Industrial Components Div.

Western Insulated Wire Co., Los Angeles, Calif. — Edward Estrin, vice-president in charge of manufacturing.

Wheatland Electric Products Co., Pittsburgh, Pa. — James F. Cook, sales manager.

Simplex Wire & Cable Co., Cambridge, Mass.—John W. Logan, executive vice president; Dr. John T. Blake, senior vice president; G. J. Crowdes, vice president.

Marcus Transformer Co., Rahway, N. J.—Edgar A. Farris, Jr., vice president, engineering.

Thor Power Tool Co., Aurora, Ill.—Peter Rebechini, chief engineer

General Electric Co., Providence, R. I.—R. E. Smith, manager of construction products sales, Wiring Device Dept.

Delta-Star Electric Div., H. K. Porter Co., Inc., Chicago, Ill.— Norman E. Shipley, sales manager, Thomas Works Plant, Lisbon, O.

Jasper Blackburn Corp., St. Louis, Mo.—W. J. Clark, sales manager.



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#### A-C MOTOR-CONTROL FUNDAMENTALS

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to work methods, useful diagrams and
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new helps. By A. M. Dudley; and S. F. Henderson, Westinghouse Electric Corp. 4th
Ed., 432 pp., 430 illus., \$13.50

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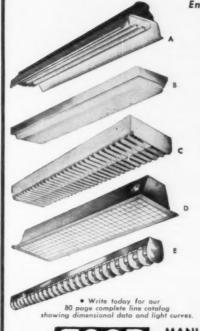
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... for ½-, ¾-, and 1-ton chassis. Electrically welded into one unit with six waterproof compartments, recessed paddle handles keyed aike and fender skirt protected with die-formed rolled edges. Built for safe, dependable service . . will outlast several chassis.

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MODEL 34 offer 15 amp., 125 volt grounded duplex receptacle with 15 amp. fuse protection. Sixteen other "Moffman" power outlets are available with choice of 15, 20, 30, 35 and 50 Ampere receptacles to fit your exact needs. Write us,

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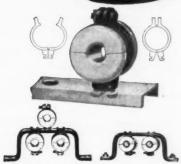






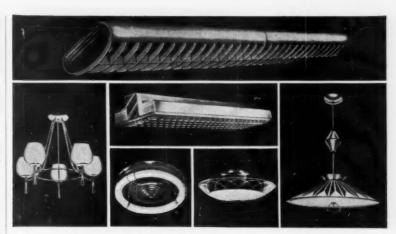
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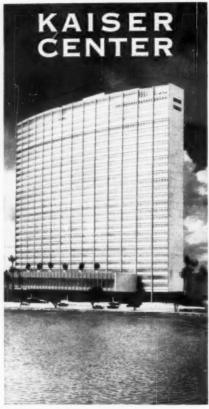
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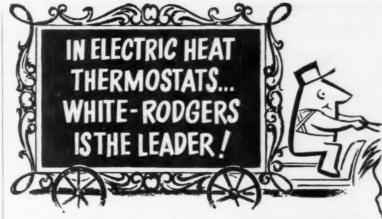
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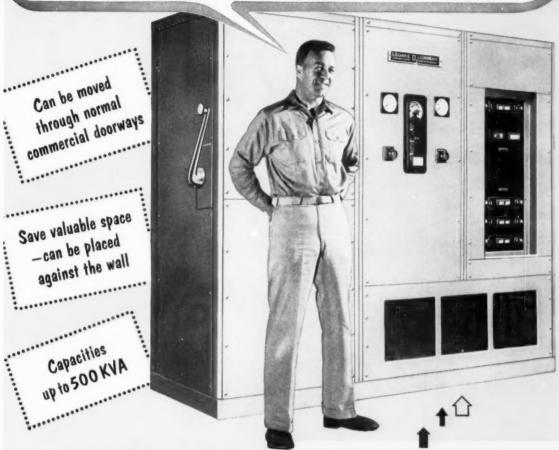
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